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DOMINION OF CANADA
DEPARTMENT OF AGRICULTURE
DOMINION EXPERIMENTAL FARMS

FRUIT TREE DISEASES OF SOUTHERN ONTARIO

IMPERIAL BUREAU
28 JUN 1921
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BY

W. A. McCUBBIN, M.A.

Assistant in charge Dominion Plant Pathological Laboratory, St. Catharines, Ont.

BULLETIN No. 24

Second Series

The Second Series of the Bulletins of the Experimental Farms treat of such subjects as are of interest to a limited class of readers and are mailed only to those to whom the information is likely to be useful.

Published by direction of Hon. MARTIN BURRELL, Minister of Agriculture, Ottawa, Ont.

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OTTAWA, January 4, 1915.

The Honourable
The Minister of Agriculture,
Ottawa.

SIR,—I have the honour to transmit herewith for your approval Bulletin No. 24 of the Second Series, entitled "Fruit Tree Diseases of Southern Ontario," prepared by Mr. W. A. McCubbin, M.A., assistant in charge of the Dominion Plant Pathological Laboratory at St. Catharines, Ont.

This bulletin, prepared under the direction and guidance of Mr. H. T. Güssow, Dominion Botanist, deals simply, yet clearly and comprehensively, with a subject of great interest and importance to the progressive orchardist—the fungus diseases which, unless controlled, so frequently cause serious injury to fruit and fruit trees. It treats more particularly of those plant diseases which have occurred in southern Ontario. Mr. McCubbin has described these diseases and their nature, furnishing information for their identification, and giving the various means to be taken for their prevention or control. It further outlines the preparation of the several fungicides to be used.

The illustrations which accompany the text, and which so greatly enhance the practical value of the publication, are from photographs and drawings by the author.

The bulletin will, I am sure, prove of much assistance to all growers of fruit in their endeavour to protect their orchards in the ever-present danger of attack from fungus diseases.

I have the honour to be, sir,
Your obedient servant,

FRANK T. SHUTT,
Assistant Director, Dominion Experimental Farms.

78212—1½

OTTAWA, March 29, 1915.

The Director,
Dominion Experimental Farms,
Ottawa, Ont.

SIR,—I have the honour to submit herewith a manuscript entitled "Fruit Tree Diseases of Southern Ontario," which has been prepared at my request by Mr. W. A. McCubbin, M.A., assistant in charge of the Branch Plant Pathological Laboratory situated at St. Catharines, Ont.

This bulletin does not aim to give a complete list of the fruit-tree diseases occurring in Ontario, nor to present a merely technical account of the diseases and fungi causing same. It has been prepared to meet the requirements of the practical fruit grower, whom it is desired to assist in the control of the destructive diseases by means of the most up-to-date and approved-of methods.

The numerous and excellent illustrations, all of which are original, will greatly assist the grower in the identification of diseases affecting the various economic crops.

Mr. McCubbin, who has for some years made a special study of the fruit-growing conditions of the Niagara peninsula, from the plant pathological point of view, has produced, in my opinion, a very useful and handy work of reference. I beg to recommend the publication of this manuscript as a bulletin of the second series of the Experimental Farms.

I have the honour to be, sir,
Your obedient servant,

H. T. GÜSSOW,
Dominion Botanist.

FRUIT TREE DISEASES OF SOUTHERN ONTARIO

GENERAL REMARKS ON DISEASES.

In order to take intelligent measures against the many diseases which infest our trees, it is essential for the grower to have a clear understanding of the nature of diseases in general, and to know at least the main features of those special ones he is trying to control. Otherwise he will be likely to slur over or omit altogether some step in the course of treatment which is absolutely essential to success. Perhaps no better case can be cited as an example than the sterilization of the tools used in cutting out pear blight. Failure to understand the importance of this step is widespread, and eight out of ten omit it altogether, with the result that the organism producing the disease is spread by saw and knife from tree to tree in a most appalling manner.

The remarks that follow are intended to indicate in a limited way some of the general features and principles which are concerned in the problem of plant diseases. They are given merely as a guide to further study of the various important points, since it is impossible to give detailed information on these within the limits of this work.

NATURE OF DISEASE.

Aside from the derangements due to climatic, physical, or chemical causes, or physiological troubles, a consideration of which will be given later, the vast proportion of ills from which plants suffer are caused by attacks of fungi and bacteria on their living parts. The injuries caused by these parasites on their hosts varies immensely. Sometimes the plant is killed outright, as in the case of damping-off fungi, while in other cases there is the barest perceptible injury to the host. Between these two extremes, all degrees of damage may be caused. The actual injury brought about in the host plant by its fungus visitor is of a twofold kind. It absorbs a certain amount of food material from the tissues of the host, but as the actual size of the parasite is so very small in comparison with the body of its host, this phase of the injury is usually quite negligible. The real damage is done by the introduction into the tissues of chemical substances which, though very small in amount, are extremely powerful in their action. Some of these have a pronounced stimulating effect on the living tissue, and incite it to abnormal growths of various kinds, while others are capable of disorganizing the living matter so completely that the part affected dies. Others again are able to break up and destroy those tissues (wood or bark) which are not in a sense living, but which are very necessary to the plant, either for protection or conducting sap.

The resulting conditions brought about in the plant are what we know of as disease, and as each fungus parasite acts in a way peculiar to itself so as to produce uniformly certain effects in its host, we are enabled in the majority of cases to judge what fungus is present, by the nature of the injury caused. In some few cases, such as certain of the cankers, rots, and leaf spots, the results produced by two or more fungi are indistinguishable to the eye, but most of the parasitic injuries ar so characteristic that they serve to indicate what organism is present even though nothing

can be seen of the fungus itself. The following common types of diseases will give some idea of the great variations in the nature of the injuries on plants due to various fungi:—

Scabs.—Spots produced on the surface of fruits by the growth of fungi thereon.

Mildews, Rusts, and Leaf Spots.—Leaves are attacked and either weakened so seriously that they are rendered useless, or else spots and dead areas are formed on them.

Wilts.—The sap-conducting tissue is invaded and so destroyed or clogged that the part of the plant above perishes from lack of water.

Blights.—Leaves and shoots are attacked and killed, after which they turn brown or black, and dry up.

Damping-off.—Several fungi attack soft-tissued plants or seedlings on the stem near or below the surface of the ground. The stem tissue is destroyed at this point, and the plant falls over and dies.

Galls, Knots, and Malformations.—The living tissue is stimulated by fungi and produces abnormal growths of various kinds.

Cankers.—Open sores on limbs which do not heal up normally but increase in size year after year.

Rosette.—Stunted growth of the stem due to fungi in its tissues. The stem remains so short that the leaves and shoots remain very close together on it.

Rots.—Destruction of fruits, roots, and woody tissue by the action of fungi and bacteria. Their tissues are usually softened, disintegrated, and discoloured.

The above short list of a few types of disease will serve to indicate to some extent the variety in the injuries caused by various fungi, and to emphasize the fact that in most cases such injury is of a specific and characteristic nature.

RESTRICTION OF FUNGI TO THEIR HOSTS.

As a general rule any particular species of parasitic fungus is able to live on but one host, or at least on a few plants closely related to each other. The Leaf Curl fungus so prevalent on the peach may occur rarely on the plum, but cannot attack the apple or pear. The Shot-hole fungus of the cherry is never found on currants and gooseberries, nor is the fungus causing the Leaf-spot of these plants ever met with on the cherry. Indeed two closely-related plants are often parasitized by two nearly-related fungi, and though the injury caused by these on their respective hosts is very similar, the fungi are really quite distinct and are unable to attack each other's host. The most familiar case of this association is that of the apple and pear scabs, due respectively to *Venturia inaequalis* (Cke.) Aderh. and *Venturia pirina* Aderh. A similar association occurs in the case of the Leaf Curl disease of cherry and peach, due in the one case to *Exoascus cerasi* (Fcl.) Sad., and in the other to the closely-related *Exoascus deformans* (Fcl.) Tul. In the case of the rusts the restrictions may include two hosts with their respective relations. The Quince Rust, which is confined to apple, pear, hawthorn, quince and similar related trees, has another stage of its life-history on the red cedar, and the Plum Rust has a similar stage on the wild Hepatica.

On the other hand there are parasites of more omnivorous habits which are adapted to live on a considerable number of hosts quite unrelated to each other. Very often a list of such hosts would include weeds and wild plants, along with one or more cultivated species, and where the former are found in or about the farm they may become a constant source of infection to the cultivated species.

NATURE OF FUNGI.

While there are quite a few parasitic fungi which have stages in their development large enough to be visible to the naked eye, yet for the most part their structure is so minute as to require the use of a microscope to determine their characteristic features. Ordinarily the vegetative part of the fungus (the mycelium) consists of fine thread-like filaments which are able to penetrate into and through the tissues of their host. It is because of this structure that an absurdly small amount of fungus can be spread throughout a large mass of its host and can accomplish results out of all proportion to its size. In certain cases, like that of the powdery mildews, where this mycelium appears on the surface of the leaf, its loose thread-like structure may be made out. As to the nature of the chemicals by which these minute and delicate filaments are able to act on the tissues of the host, very little is known, but it must be conceded that they are very efficient means for the purpose, since such extremely minute quantities as could be produced by the fungus filaments are able to bring about important and far-reaching changes in the host.

Fungi reproduce by means of spores, which are very minute parts formed from the fungus body, and which answer in function to the seeds of higher plants. Without the use of a microscope, it is very difficult to comprehend how extremely minute are the spores of fungi, or in what extraordinary numbers they are produced. A bag of wheat reduced to the size of a period (.) would be a fair comparison for one of the spore-filled pustules of the blight fungus on the peach twig. There are only a few cases where spores are so large that one of them can be seen by the unaided eye, and of course their structure could not be made out in any way. Under the microscope, however, spores are seen to be quite varied in size and shape, and to be as definite for their species as grains or fruits are for higher plants. Some few of their numberless forms and shapes are figured below (figs. 1 to 18) as well as several of the characteristics methods in which they are produced. As these spores are all magnified to the same extent, it will be seen that they have considerable variation in size as well as shape.

EXPLANATION OF FIGURES ON PLATE—FIGS. 1 TO 18.

1. Section through the skin of an apple destroyed by Black Rot (*Sphaeropsis malorum,* Pk.). These black spore-producing bodies (*pycnidia*) of the fungus are shown just at the break they have made in the skin. One of these contains a few spores still, but the most of them were washed out in making the section.

2. Three Black Rot spores enlarged.

3. Spores of the Quince Rust (*Gymnosporangium* sp.) from one of the orange spore cases on the fruit.

4. Pink Rot of apples (*Cephalothecium roseum,* Cda.). A head bearing immature spores is shown in outline, and one mature spore is also figured.

5. Spores of the Shot-hole fungus (*Cylindrosporium padi,* Karst.) from a cherry leaf.

6. Spores of the fungus causing Pear Leaf Spot (*Septoria piricola,* Desm.).

7. Spores of the Blight fungus from a peach twig.

8. Part of a spore-bearing filament of the Peach Mildew [*Sphaerotheca pannosa* (Wallr.) Lév.] and a single ripe spore. The spores drop off from the end of the filament as they ripen.

9. Spores of *Alternaria,* a very common fungus. Several species of this genus are parasitic.

10. Four spores from a Quince Leaf Spot [*Fabraea maculata* (Lév.) Atk.]. Their appearance is quite characteristic on account of the spine-like processes which they bear.

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11. One of the fructifications of the Powdery Mildew of the grape [*Uncinula necator* (Schw.) Burr.].

12. The same burst open showing the spore-sacs (*asci*) protruding from the rent.

13. A single spore-sac (*ascus*) of the Powdery Mildew. The spores are shown in outline within it.

14. Three spores of the Downy Mildew [*Plasmopara viticola* (B. and C.) B. and de T.] from a grape leaf.

15. Part of a spore-bearing filament from a pustule of Brown Rot [*Sclerotinia fructigena* (Pers.) Schr.]. The drawing is in outline only, and shows the manner in which spores are produced.

16. Three mature Brown Rot spores.

17. Outline drawing of four Brown Rot spores germinated over night in peach juice. Several stages in germination are shown. The filament running off at the bottom of the page was so long that another foot of paper would have been necessary to represent it all.

18. The relative sizes of the spores and the drawings of them, i.e., the magnification of the figures, may be realized to some extent by comparing the small black area indicated with the whole page. The drawings are magnified approximately this amount, with the exception of Nos. 1, 11 and 12, which are magnified only one-third this amount.

TRANSMISSION OF SPORES.

Just as in the problem of weed control, the important feature is that of seed dispersal, so in considering the spread of fungus diseases the main interest must centre around the question of spore dissemination, for it is evident that it is almost entirely to these spores that the yearly recurrence and spreading of diseases is due. Among the various agencies which bring about the transport of spores there is scarcely any doubt that the wind is the chief offender. On account of their small size these minute bodies are carried very readily by the wind, and they may travel considerable distances in this way. Probably the most effective work of the air currents, however, is in connection with the reinfection of trees and shrubs locally from the spores of last year's leaves and fruit, and it is highly probable that a good deal of leaf spot and fruit rot infection is brought about in this way. Insects are notorious as spore carriers, and many diseases such as Pear Blight owe a good deal of their wide occurrence and numerous infections to the good offices of flying insects. Birds and small animals are also instrumental in the spread of spores to a limited extent. A good deal of spore dispersal must be attributed to rain, both by reason of the streamlets and freshets caused by it and also because of the spattering action of the raindrops themselves. There can be no doubt that a great deal of infection must arise in this way, particularly when one considers that the spore is accompanied to its new locality by that which is very necessary to its germination, viz., a drop of water. Another important factor in the transport of disease spores is man himself, and through his various activities a great deal of distribution is brought about. His tools, carriages, domestic animals, and the various articles he is always exchanging with his fellows or buying for his own use, bear on and about them quite a number of spores of various kinds, some of which may establish themselves on his farm. Threshin machines are notorious for dispersing weed seeds, and they are just as effective in distributing spores. Hay and feed of all kinds, vegetables, marketed fruit, roots, and seeds, all help more or less to keep up local infection. During more recent years there has been a tendency to import plants from foreign countries, and many harmful diseases are liable to be introduced in this way, not alone because of diseases already established in the plants themselves, but by means of spores which may be adhering to them or may be carried in the packing around them. Laws prohibiting the importation of some stock, and requiring the rigid inspection of others, have been found

necessary to protect us against these diseases. Care in this matter is the more needed because, like the rabbit in Australia or the English sparrow in America, a disease comparatively harmless in its native place becomes sometimes very destructive when established in another climate.

RESISTANCE OF SPORES TO CONDITIONS.

In passing from one host to another the spores of fungi have not the power of accomplishing or even directing their own movements, but depend on good fortune or lucky chance to bring them to their destination. Naturally under such circumstances a large proportion of them must "fall by the wayside" and probably not one in a million reaches its proper host again.

In regard to these strayed spores, the question of longevity is important from our point of view, for the longer they live the greater chances there are for them to be carried back to their hosts. In the few cases that have been determined the life limit shows great variation. The spores of Brown Rot for instance do not remain alive for more than a few months, while those of Black Rot have been known to germinate after being kept two years in the laboratory. Some soil diseases infest the land for five or six years or more after an infected crop has been grown on it, even though the host was not planted in the intervening time. It is probable, however, that the greater number of fungus spores under field conditions perish from age in one or two years, just as seeds lose their vitality after being kept for a time.

In regard to other conditions which might be expected to affect the life of spores there may be mentioned temperature, particularly extreme cold. It has been found, however, that low temperatures have little if any effect on fungus spores in general, and that they pass through our severe winters unharmed.

Light is another factor that must be taken into account, and it is interesting to note that strong light possesses a distinct fungicidal value, and in many cases fatal to the spores of fungi and to bacteria. It may be mentioned in this connection that the Pear Blight organism is killed by an exposure of fifteen or twenty minutes to the sun's light.

Usually fungus spores are able to withstand drying up without injury, but, on the other hand, it is quite probable that since most spores germinate readily in water vast numbers of them begin to grow if deposited in moist situations, and the fungus, being unable to secure nourishment away from its host, perishes in a short time, just as seeds do when grown on damp blotting paper.

WINTERING OF DISEASES.

Many of our most destructive diseases such as Peach Leaf Curl, Apple Scab, Currant Leaf Spot, and Grape Mildew, are found mainly or altogether on the leaves and fruit of their respective hosts. As these leaves and fruit fall and are renewed each year, there must necessarily take place each summer a new infection. This brings up a very important phase of the study of plant diseases: How do fungi pass the winter, and how does infection begin again in the spring? It is obvious that spores must be transported from the old foliage or fruit to the new, and if the habits of the fungus in this respect are determined with certainty it may be possible to prevent next year's infection by some suitable means. A number of possibilities present themselves in a consideration of the question of hibernation or wintering: —

1. The fungus may remain over winter in cankers, dead twigs, and other parts which are not shed in autumn, as in the case of the Black Rot on apple trees.

2. Spores may be produced in abundance during the summer, and these are left adhering to buds and twigs in sufficient numbers to start infection next year, as happens in the Leaf Curl disease of peach.

3. The old fallen leaves may produce a fresh crop of spores in spring, whereby the next year's infection is secured.

4. The fungus wintering over in last year's leaves or fruit may, in spring, produce a new crop of spores, but of a different sort to those formerly produced.

5. The fungus may pass the winter on another host, a customary method among certain rusts.

6. Many fungi of the rot-producing type live so universally in dead wood and other vegetable matter of various kinds that they are always more or less present everywhere. The green mould (*Penicillium*) causing an apple rot is a familiar example of this type.

In some cases sufficient knowledge has been obtained regarding the means by which one year's disease passes its infection over to the next to enable us to entirely protect a season's foliage or fruit from attack. The methods used vary with the disease, but they genereally comprise:—

1. The destruction of the infected leaves or fruit of the preceding year.

2. Destruction of spores lodged in the trees by means of suitable fungicides.

3. A protective coating of the tree with some substance which prevents the germination of spores which have been missed by (1) or (2), or which may be brought in from elsewhere.

The methods used in the successful control of leaf and fruit spots such as Apple Scab and Peach Leaf Curl are based on these principles. In the case of such diseases as involve a more or less continuous infection throughout the summer, the main reliance must be placed on the third method. Where the time of infection is very early in the season, the first and second methods are of the first importance.

INFECTION.

In the question of infection, three considerations arise: (1) a host, (2) spores of the fungus, (3) conditions suitable for the germination of these spores. The conditions under which the spores of various parasitic fungi are able to attack a host vary a great deal, and infection is often subject to such severe limitations that if it were not for the immense number of spores produced the fungi thus limited would never be able to maintain themselves. It should be our aim to learn as much as possible concerning these limiting factors, and to encourage them as far as we can. Among these conditions the susceptibility of the host is the important one. Some varieties fall easy victims to a disease which scarcely affects others. In peaches, the "Toronto" and "Brecken" are very liable to attacks of Mildew and "Hill's Chili" to Scab. Similarly, Pear Scab occurs much more severely on "Duchess" and "Flemish Beauty" than on "Bartlett" and "Kieffer," and among apples, Scab is particularly bad on the "Snow" varieties. Hence it is always wise in planting out new varieties to look carefully into the question of their susceptibility to disease. Another factor of great importance in the question of infection is the inability of some fungi to enter their hosts except under special conditions. The bark of plants is extremely resistant to fungus action, and, if kept intact, forms a perfect protection against many enemies. The Black Knot fungus seems to be unable to infect a limb of cherry or plum unless there exists some lesion of the bark, and most of the fungi causing wood rots are similarly dependent for their entrance on a wound, a dead limb, a bruise, or a crack. One can materially help the plant to use this natural means of protection by making as few wounds as possible either on the trunk, limbs, or roots. Where these are unavoidable as in pruning, all large wounds should be covered by a coat of tar or paint, which will take the place of their natural protection until growth has covered these wounds again.

Various other fungi have similar narrow limits within which they can attack their hosts. The period of infection for Leaf Curl is over when the young tender leaves in the buds have expanded and their moisture content is lessened. Others, like the Tomato Leaf Spot and Shot-hole fungus, seem unable to gain a foothold until the leaves become weakened by age, disease, starvation or drought. Fruit rot fungi, which are often able to penetrate the unbroken skin of the fruit, find entrance much easier by way of wormholes, bruises, cracks, or scab spots.

Again, fungi are very often restricted to one particular part of their host, and if they are able to attack other parts, such infection is usually difficult and of little moment. Brown Rot does not affect leaves or branches of the plum, but only the fruit. Black Knot is only found on the limbs of plum and cherry, Leaf Curl of Peach rarely if ever occurs on the fruit of the peach, and the well-known Shot-hole is strictly a leaf disease.

Among the various climatic or physical factors which limit infection, the necessity for water is very important. A spore falling on a suitable part of its host is unable to germinate unless water is present and if this moisture should dry up before the growth from the spore has penetrated into the host, the spore may perish. In the case of some fungi the dewdrops may furnish sufficient water, and germination may occur over night, while other more slowly growing spores require many hours more than this to effect their entrance, and hence are dependent on rain or fog to give them a chance to establish themselves.

Heat also plays an important part in the process of infection, and conditions of combined moisture and warmth are especially favourable to spore germination.

Among the remaining factors which at times check or facilitate the activities of parasitic spores must be mentioned the condition of health of the host itself. Some diseases make severe attacks only when the vitality of the host has been lowered through some cause. Of such a nature is the Shot-hole fungus on the peach, which rarely does much damage to adult vigorous trees but may seriously defoliate those which are young or in a weakly condition. In a similar way the Pear Leaf Spot is most prevalent and destructive on starved, winter-injured, or otherwise unhealthy trees.

A knowledge of the various natural checks to infection, both in regard to disease in general and to individual cases, is a very important aid in the fight against these parasites, and every means should be taken to raise the barriers higher and to set the limits that nature has made still closer together.

METHODS OF MEETING DISEASES.

1. *Planting of resistant varieties.*—If it were possible to procure stock bred so as to be immune from all or even from the more serious diseases, such a method of dealing with diseases would be by far the most satisfactory for the fruit grower; for once a resistant variety was established in his orchard, he would never thereafter be subject to either loss from attacks of disease or the expense of spraying or otherwise treating it year after year. Unfortunately we are not yet in a position to realize such a happy state of affairs. The science of plant breeding is still in its infancy, and many of the laws relating to it are still imperfectly understood. It must be remembered also that the slowness of growth of fruit trees, especially apples, renders such work very difficult and tedious, so that many years must necessarily pass before we can hope for very much in the way of practical results. In certain cases the outlook in this field is promising. We already have varieties more or less resistant to different diseases. There are a few varieties of the apple that are seldom seriously affected by Scab, and the partial immunity of the Kieffer pear to Pear Blight is well known. If the resistant properties of such varieties could be induced by selection in others less favoured, or transferred by crossing to some of their unfortunate relations whose fruit has a higher commercial value, it would be a veritable godsend to the fruit growing industry. We cannot, however, overlook the fact that many of the so-called resistant plants now on the market are not wholly immune, nor the equally important fact that immunity is often a local quality holding only for a particular region or under certain conditions of soil and climate.

2. *Control of conditions favouring disease.*—Methods coming under this head are necessarily restricted in their application, since many of the conditions, like heat or

rainfall, are beyond our control. Still there are some diseases which may be checked, lessened, or even prevented by timely attention to factors more or less subject to our control. Shot-hole fungus on the peach usually appears on weakly, ill-nourished, or diseased trees; Pear Blight is encouraged by trees making soft rapid growth; close thick-headed peach trees favour infection from Brown Rot; Mildew on grapes is more troublesome on sand than on clay land; storage rots of fruits are likely to make vigorous growth in a warm, moist atmosphere. In all these cases, and numerous others that might be mentioned, the disease can at least be lessened by control of the obvious factor which is favourable to its progress.

3. *Using clean seed and nursery stock.*—There are certain diseases which are not universal in their distribution or which are not readily spread by other means, in regard to which this precaution is necessary. Soil diseases like the Potato Scabs, Yellows and Little Peach, and Crown Gall are examples of such diseases. Where possible, one should try to make sure that all seeds and nursery stock planted have been grown under clean conditions and are not likely to add to his troubles by the introduction of a new pest on his farm.

4. *Planting in clean soil.*—In cases where it is known or suspected that soil-infesting diseases are present in a piece of land, care should be taken to put in it only those plants which are not liable to the disease. The most important diseases towards which care should be exercised in this respect are Crown Gall, the Potato Scabs, and Club Root of Cabbage.

5. *Preventing Infection.*—A large number of the ordinary operations that take place each year in the orchard or garden may be made to assist in the work of preventing the spread of disease and lessening infection, aside from the special means that may be adopted in controlling the various diseases. The work of pruning is especially important in this respect. At the time when a tree is being trimmed, all dead or cankered limbs, which are often a breeding place for such fungi as the Black Rot of apples, should be cut out. Such branches are especially undesirable from the fact that their loose and roughened bark and the splits in their wood are apt to retain spores which sprays will not reach and which later may fall or be blown to other parts of the tree. It is needless to add that all such material should be burned forthwith. On the other hand, the pruning knife and saw may be instrumental in carrying infection from one tree or limb to another, especially in such cases as Pear Blight, and it may be necessary to use a disinfectant of some kind on the tools after each operation. (See fig. 33, p. 35.)

Another fruitful source of infection lies in the fallen leaves and fruit. The best and surest way to get rid of these would be, of course, to burn them, but this would involve a great deal of time and labour, and it is not to be thought of in commercial orchards. The next best thing is to plough them under. If well covered, very little harm can come from them afterward, but it is usually very hard to bury leaves completely. Some are sure to remain uncovered, and often ploughing is finished before all the leaves have fallen. A little extra attention in this work so as to ensure more complete burial would be well repaid.

Attention might also be directed here to a number of other places about an ordinary orchard where leaves and fallen fruit may collect, and where their fungus parasites may find comfortable winter quarters. Such are to be found in piles of stone, rails, wood or brush, and, perhaps worst of all, the crooked rail fence with its accompanying strip of sod. If the fungus inhabitants of leaves and fruit were gifted with feeling, one can imagine the prayer of gratitude that would arise from those which chance winds deposited in the ideal safety of some sheltered grassy fence-corner. It is hopeless to try to effectively control a disease by spraying, when the means of infection is neglected in this way.

Another point that may be incidentally looked after in preventing infection is in the removal of other hosts. Often weeds are attacked by the same fungus that occurs on a cultivated plant, and they help to carry it over even if crop rotation be practised. Crown Gall is of this nature, and may be found on a number of wild plants. The "Finger and Toe" disease and the Blister Blight of Crucifers (cabbage, cauliflower, etc.) may occur on such weeds as mustard or shepherd's purse, and thus be carried over two or more years. The Quince Rust has its other stage on the Red Cedar, and comes to the quince each spring from that host. Pear Blight is known to occur on the hawthorn and other related wild plants, and these may prove a source of infection to evenly a carefully tended orchard. It will pay well to keep a careful lookout for these other hosts, and to remove them if they are suspected of disease.

Some special means of preventing infection may be given as follows:—

(*a*) The painting of wounds and pruned surfaces with paint, tar, whitewash, or other similar protective substance to prevent the development of fungi in the exposed tissue.

(*b*) Killing the fungus already present on the leaves and fruit, as is done in the case of Grape Mildew by the use of powdered sulphur. Such a method is only possible in a case like this, where the fungus is external.

(*c*) Disinfection of seed, etc., before planting. Treatment of Potato Scab and Wheat Smut with formalin are examples of this process.

(*d*) Soil sterilization to destroy soil fungi before planting a susceptible crop.

(*e*) Excision of affected parts to prevent the fungus or bacteria from extending into other parts of the plant.

(*f*) A cleansing spray, or dormant spray, to kill all spores on the tree before growth starts in the spring is the most common, simple, and effective means we have of dealing with a number of annual diseases. On account of the greater resistance of the dormant wood to the action of chemicals, much stronger spray mixtures can be used in this case than where foliage is present. (See p. 31.)

(*g*) A protective spray is often employed to cover foliage or fruit with a substance poisonous to fungi and their spores, but harmless to the host plant. It is used in diseases where continuous infection is likely to take place from without, or where infection is likely to spread rapidly on the leaves and fruit of the plant itself. For the various spray mixtures, employed for this purpose, see p. 68.

OTHER CAUSES OF UNHEALTHY CONDITIONS.

WINTER INJURY.

This term may be used to include a number of fruit-tree troubles brought about at the time when the tree is either dormant, about to become so, or is emerging from the dormant condition. While low temperature is the chief factor to be considered, a number of others play important parts in conducing to the results. There is quite a variety in the nature of the injuries produced, but the chief types only are given a brief discussion.

Dieback.—Perhaps the simplest and commonest case of winter injury is thus named. Twigs and small branches die during the winter for distances varying from a few inches to several feet. It is a common occurrence on shrubs and trees not quite hardy for the district, as in the case of the mulberry in the colder parts of Ontario. It is worthy of note that this death of the shoots is a mild form of what normally occurs in the case of our herbaceous perennials in which the year's growth dies down to the ground every fall. Frequently, however, hardy trees suffer the loss of twigs

and shoots, especially if their vitality has been lowered from any cause. Dieback is common on the peach and also on the Japanese plum, especially in the case of such varieties as the Burbank and Abundance. Raspberries also very commonly lose the ends of their canes in this way.

Bud Injury.—Extreme low temperatures are liable to kill the buds of several trees and shrubs, particularly those of the peach. In the case of this tree, the danger line is supposed to lie at about fifteen degerees below zero Fahrenheit, and the results are likely to be more severe if the low temperature is long continued or is abruptly preceded or followed by warm weather. In the less favoured parts of Ontario, the winter killing of buds is a frequent source of loss in peaches.

As noted under the peach, another form of bud injury may occur in which the injury from the frost is more or less mechanical. In such cases, the expansion of sap in freezing in the water-gorged tissues bursts the buds from the twigs, a condition of things usually only met when a late frost occurs in the spring after the buds have swelled. As the flower-buds are further advanced than leaf buds, such damage is likely to be severest on the former, and the leaf buds may be but little affected.

Sun Scald is another form of climatic injury very serious in its results, and from its prevalence throughout the country and from the lasting nature of the injury, the losses from this source are quite considerable. Sun Scald may occur on the limbs or trunk of almost any of our fruit trees. On pears and plums, the trunk is usually affected, while, in the case of apple trees, exposed limbs may be scalded as well as the trunk. The trouble is apparently due to severe frost following bright warm sun. The south or southwest side of the tree, or in the case of the limbs the upper side, is heated during the day by the sun's rays, and reaches a higher temperature than the surrounding air. The sudden drop in the temperature, which then occurs at night or by reason of more severe weather, results in the death of the bark and living tissue on this side. The size of the areas so killed is variable. In some cases, only a small narrow strip dies, while in others half the trunk may be involved. Where conditions of soil and culture are uniform and the same varieties are planted, the injury is likely to occur on all the trees, so that it is not uncommon to see an orchard in which nearly every tree bears a long sun scald wound down the trunk. If the injury has not been too severe, the tree recovers, but it must necessarily be a weakened tree forever after. Besides the actual loss of growing and conducting tissue, there is always afterwards the constant danger, almost the certainty, of the entrance of rot fungi into the wound, which so weaken the trunk that the tree may be expected to die entirely after a few years of sickly life.

Crown or Collar Rot.—These terms have both been used to describe injury at or near the surface of the ground, often involving the roots as well. In a few exceptional cases, this effect may be brought about by other causes, but the great majority of such injuries must be ascribed to a form of winter-killing. Pear trees seem to suffer a great deal in this way, and apples, peaches, cherries, and plums (especially the Japanese varieties) are all more or less affected. Trees injured in this manner are usually found in a soil either lacking in humus or containing too much water. When examined, the crown or base of the trunk and part or all of the root system have the living outer tissues browned and dead. Such trees may put out leaves and blossoms in the spring following the injury, but when the dryness of the summer comes on they suddenly wilt and die. Partially injured trees may live on for some time, but they may be distinguished by small sickly leaves and lack of growth. Such symptoms may sometimes be seen on one side only, the trunk having sustained injury below the sickly portion.

Frost Brown, Heart Brown, Black Heart.—Occasionally trees or whole orchards are met with in which a distinct browning of the heart wood has taken place. This condition is usually due to severe frost occurring at a time when the tree is ill-prepared to meet it. Young trees often suffer from it, but older trees are by no means

exempt. If the injury is not too severe, the tree does not seem to suffer materially, and grows as usual afterward. In a case which recently came under the writer's notice, fifty peach trees, all vigorous and growing well, were found to be browned in the heart wood. From the evidence of the yearly rings of growth, the injury must have occurred during the winter of 1910-11, but the trees had not been set back by it, as shown both by the thickness of the succeeding rings, which were normal in colour, as well as by the twig growth of the succeeding years.

Frost Burn on Leaves.—Under certain conditions, leaves are liable to be killed or injured by spring frosts when they are young and tender. If at this time a severe frost at night is followed by a bright, hot morning, a good deal of leaf injury may result. If such leaves are allowed to thaw gradually, little harm follows the frost, but sudden heat destroys the leaf cells before they have had time to reabsorb the water driven out by freezing. Those leaves which emerge from the leaf bud folded are apt to have that part injured which is at the crease, and when the leaf unfolds a narrow streak is seen to be killed. In other cases the tips and edges of the leaves are browned.

All the above forms of injury may without doubt be ascribed to winter conditions, but it is not always to cold alone that they are due. Vegetable tissue under certain circumstances will withstand very low temperature unharmed. Seeds have been kept for days in a bath of liquid air, and afterwards showed almost normal germination, while on the other hand fleshy leaves are killed by a few degrees of frost. From such facts, as well as by observations and experiment, it has been determined that the amount of moisture in the plant tissues is the principal factor concerned in liability to frost injury. The process of ripening the wood in the fall has for its chief aim the elimination of surplus moisture from the tree, and under normal conditions this would readily be accomplished. There is usually a steady decrease in the rainfall during the months of August and September, and the soil supply is less at that time than in the spring months. The tissues themselves undergo changes which tend to get rid of their surplus water, and new growth which requires abundance of water, entirely ceases. Any factors, therefore, which tend to interfere with this natural preparation of the plant for winter are likely to be a cause of winter-killing in one form or another.

Among such factors may be mentioned the following:—

1. "Wet feet" or the presence of too much water in the soil, due either to lack of drainage or to excessive rainfall, or both.

2. Warm weather in late fall, especially if accompanied by abundant moisture encourages late growth, and leaves newly-formed, unripened, and water-soaked tissues to meet the winter.

3. Late cultivation, which tends to conserve the soil moisture when it should be allowed to evaporate.

4. Severe summer pruning, which is liable to stimulate late growth.

5. Defoliation of a tree in summer or spring by insects or fungi, if severe, often causes a second production of leaves and shoots which are likely to be immature.

6. Low vitality of the tree. A study of the severe winter injuries which occurred in Ohio in 1903-4 showed that trees of impaired vitality are more liable to suffer than those in vigorous and healthy condition. Such low vitality may result from a number of causes, as, for instance, lack of nourishment, attacks of disease, insect injuries, overbearing, and transplanting.

It was also evident from these investigations that a sufficient amount of humus in the soil was a protection, presumably by preventing it from freezing too deeply; and that a cover crop, a mulch of leaves, straw, or barnyard manure, or even a bank of earth around the trees were excellent means of helping them to tide over the winter safely.

It must not be thought, however, that it is always weak or imperfectly ripened trees which suffer from winter conditions. In occasional winters, when there is severe,

long-continued cold, trees are injured which entered the winter in sound and healthy condition. Such instances can only be ascribed to extreme temperatures. But fortunately such seasons are rare, and the cases of injury to healthy trees arising from them more or less local.

From a consideration of the preceding pages, it will be seen that any attempts to deal with winter injuries must involve two lines of procedure, that of prevention in the first place, and secondly, a treatment of trees that have already suffered damage. Concerning prevention, little can be added to what has already been said, but the following hints may summarize the situation:—

1. Plant only varieties known to be hardy for the locality.
2. The soil must be well drained. If not so by nature, a system of underdrainage should be put in. Few fruit trees thrive on wet soil.
3. Trees must have sufficient nourishment to ensure their vigour.
4. A soil containing a plentiful supply of humus does not freeze so deeply or so hard as an earthy soil, so that cover crops and barnyard manure are helpful.
5. Late cultivation, which tends to conserve moisture and encourage late growth is to be avoided.
6. Severe summer pruning, which also has a tendency to stimulate late growth should not be given.
7. Defoliation from insects and fungi should be prevented.
8. Any causes which tend to weaken the tree render it more or less liable to winter injury. Attacks of borers, rusts, mildews, leaf spots, and cankers may all contribute to this result. In short the whole matter of prevention as far as it concerns conditions under our control may be summed up in these words: A healthy tree—ripened wood—protective conditions.

Treatment of trees which have suffered from winter-killing in its more serious forms is usually a very unsatisfactory process, especially where the injury involves a considerable part of the tree, as in Sun Scald or Crown Rot. When large areas on the trunk are killed, the heart wood is exposed to the action of insects and rot fungi and, after a year or two of their action, the whole centre of the tree becomes soft and rotten. Besides weakening the trunk mechanically, this decay of the heart wood provides a haven of refuge safe from the most searching spray for all manner of insects and fungus spores, and the chemical products arising from the process of decay make their way slowly into other living parts of the tree, where their action has a very deleterious effect. All these secondary effects arising from Sun Scald, etc., may in a measure be avoided by covering the dead area with some protective substance as soon as the injury is discovered. Any substance like tar, whitewash, or paint may be used for this purpose, but any ordinary paint is perhaps the best and easiest to apply, and is lasting. A good coat of it on the wood (not the bark) of the dead area will preserve it in a sound condition for several years.

Bridge grafting is a method employed in certain cases to connect the trunk and roots of a valuable tree where it has been nearly or quite girdled. It should be accompanied by a reduction in the top.

Where limbs are sun-scalded or twigs killed, it is advisable to get rid of them as quickly as possible. Twigs very soon after death are attacked by various fungi which may be parasitic and may use this situation as a breeding ground from which other parts of the tree may be infected. On the plum and peach, *Valsa leucostoma* is very common on such twigs, and on the apple, Black Rot is frequent, with occasionally some cases of Bitter Rot. The Black Rot fungus is especially partial to the Sun Scald areas on the apple, where it remains for two or more years. Besides the actual danger of these fungi advancing into the adjacent living parts of the tree, it is bad policy to allow them such a favourable breeding ground, from which to spread their spores to other parts of the orchard.

OTHER CLIMATIC INJURIES.

While by far the most serious damages due to climatic causes are those resulting from winter conditions, a few other climatic injuries may be mentioned. Burning of the leaves by heat and drought is common, though rarely serious. A wet period of growth, in which the leaf tissue develops in a soft and tender condition, followed by hot and dry weather, often results in the killing of the leaves wholly or in part. The tips and edges are most commonly the parts destroyed, and injury of this sort is often mistaken for the work of fungi.

Under similar conditions, such shade-loving fruits as the goooseberry are liable to scald and drop. The English gooseberry often suffers in this way, especially if the bush has lost its foliage and the fruit is exposed directly to the sun.

Hail is sometimes very damaging to both fruit and foliage, and the limbs of trees are occasionally found scarred and pitted by its action.

Of recent years the rapidly-increasing automobile traffic on our roads has brought into prominence the dust problem. Besides the deposit of objectionable dust on marketable fruit, there is no doubt that the layer of dust on the leaves of plants impairs their food-producing capacity. In some cases attempts have been made to reduce the effects of this nuisance by planting dust barriers of fir or other thick-growing trees along the roadside.

UNHEALTHY CONDITIONS DUE TO SOIL TROUBLES.

It is not within the scope of this bulletin to deal with this subject in detail, but it may be pointed out that in many cases where plants are sickly the condition of the soil may be to blame.

Soil poverty is a frequent cause of such ill health. If one or more of the several food constituents necessary to the plant are insufficient or lacking it cannot make a strong, vigorous, and healthy growth, and is very liable to the attack of other diseases.

Excess of some substance in the soil may also bring about a similar retardation of growth and weak vitality. Acid or "sour" soils, and those containing too much lime, are both undesirable for ordinary fruit trees.

The amount of water in the soil has an important bearing on the health and growth of the trees set in it. "Wet feet" is a frequent trouble, for where there is excess of water in the soil fruit trees do not thrive. The peach especially requires a well-drained soil, and though the plum will grow in damper situations than the peach, all fruit trees reach their best development in land that has good drainage. A wet soil is very conducive to Collar Rot and other forms of winter injury.

The tilth or texture of the soil and the amount of humus present in it are also factors which it is important to consider. As previously pointed out, trees in loose, humus-filled soils are not so liable to winter injury as they are in hard, earthy soils. Collar Rot is especially prevalent in the latter type of soil.

PHYSIOLOGICAL TROUBLES.

Besides the above-mentioned types of diseases, there are certain others, which are apparently not due to organic parasites or to external conditions, but to some inherent defect or derangement in the plant itself. It is at present considered that the Mosaic diseases of various plants, Raspberry Leaf Curl, Peach Yellows, and Little Peach belong to this class. In these diseases, no organism has been shown to cause the disease, and they are evidently not due to climatic or soil conditions. It has been suggested that some disturbance has occurred in the enzymes (ferments) of these plants—the enzymes have become abnormal in some way—so that the ordinary functions of growth are interfered with. Just how near this hypothesis may be to the truth there is no present means of judging, but there is no doubt that careful research will presently throw some light on the causes of these obscure diseases and give us a means of controlling or avoiding them.

IDENTIFICATION OF DISEASES AND ADVICE REGARDING TREATMENT.

Aside from the diseases described in this bulletin there are quite a number of others which may be expected to occur from time to time on fruit trees and shrubs, but which are usually so scarce or unimportant that they have not been included in this list. There is always a possibility that some of these may become so prevalent under special conditions that they may cause considerable damage, and it is necessary therefore, to be able to obtain additional information regarding such special cases. Moreover, the danger of the introduction of serious diseases new to this locality ought to make the fruit grower careful to investigate any new and unknown fungus visitor as soon as it appears. In either case the grower should avail himself of the assistance of the Dominion Department of Agriculture, which, through the Division of Botany, will be glad to give all possible information, without charge, regarding special cases that may arise, or to assist in the recognition of any disease the identity of which may be doubtful. Whenever information regarding a disease or its treatment is desired specimens of the affected plant or of that part of it which is attacked should be sent to—

The Dominion Botanist,
Central Experimental Farm
Ottawa,

Who will give it prompt attention. In sending such specimens, the following points should be observed:—

(*a*) A sufficient quantity of typical material should be sent.

(*b*) It should be packed so as to arrive in good condition.

(*c*) The package should be plainly marked with the name and address of the sender.

(*d*) If not above 12 ounces in weight, it will go postage free to the address given. More than one package may be sent.

(*e*) A letter should be sent at the same time to the Dominion Botanist (this will also go postage free) stating the extent of the trouble, damage caused, and all other particulars that can be given concerning it.

APPLE.

Baldwin Spot (*Cylindrosporium pomi* Brooks).

This apple spot has received its name from the frequency of its occurrence on the Baldwin, though it may occur on other varieties as well. It begins in July or August as a small spot on the surface of the apple just under the epidermis. Later on it increases somewhat in size, and the flesh beneath the skin becomes brownish and somewhat dry. Such dead spots rarely exceed a quarter of an inch in diameter, and may be considerably less. They may be present in considerable numbers on a fruit, and, as a rule, are more numerous toward the blossom end. The disease is attributed to the fungus *Cylindrosporium pomi,* which invades the fruit through the lenticels or air pores on the skin. It has not proved sufficiently troublesome in the Niagara region to warrant special treatment, but United States pathologists state that late spraying with Bordeaux is an effective remedy.

Several fruit spots of a similar appearance, but due to other causes, have been recorded (fig. 19). The well-known "Stippen," in which the brown spots occur throughout the flesh of the apple, as well as on the surface, is apparently not due to a parasite, but is the result of drought following a period of damp weather and rapid growth. Another spot of like nature is said to be caused by Bordeaux mixture, and still another in stored apples to the effects of ammonia or carbon dioxide gases.

Bitter Rot (*Glomerella rufomaculans* (Berk.) Spauld. and Von Schrenk).

The Bitter Rot fungus is very destructive in Central United States, but though it occurs with us it is of much less importance than Black Rot. It is not at all common on fruit, is found occasionally on dead and dying twigs, and may possibly form limb cankers, though most of such cankers in the Niagara region are apparently due to the Black Rot fungus.

Of the three methods of attack mentioned, the fruit rot is the most important Some infection may occur early in the season, but the chief damage is done at the time of ripening. After infection, which may take place either through a break in the skin or through the uninjured surface, a small brown spot is formed, which increases in size and becomes somewhat depressed. Later on, as the rot progresses, small black spores pustules appear under the skin around the centre of the spot. These are often arranged in concentric rings, and from them the spores are extruded in small pink tendrils. When the rot has involved the whole apple, it dries up, wrinkles,

Fig. 19
An apple Fruit Spot.

and turns black. The mummy thus formed remains over winter, and the spores on it are capable of renewing infection in the spring.

It is claimed also that this early infection may be begun by spores produced from twigs or from Bitter Rot cankers on the limbs, and in certain cases cone-like areas of fruit infection have been observed to extend from these sources.

Satisfactory results have attended the use of sprays in controlling this rot. Bordeaux mixture is used for the purpose, and the first application should be given about five or six weeks after the petals have fallen. Three or four other applications should follow at intervals of two weeks, or less than this if the weather is wet. So far as the writer's experience goes, this disease is not of sufficient importance in the Niagara peninsula to necessitate any special measures.

Black Rot (*Sphaeropsis malorum* Pk.).

This is the most serious rot disease of the apple in Ontario. It may attack the fruit on the tree, but is usually far more prevalent on fallen apples or on those in storage, and it is particularly on the latter that its destructiveness is important. The

infection of fruit is greatly assisted by the presence of wounds, insect punctures, worm-holes, and bruises, but under certain conditions the fungus is able to penetrate the apparently uninjured surface. The small brown spot arising from infection enlarges rapidly and extends deeply into the tissue of the fruit. When the apple is kept in a cool place, the development of the fungus is slower and the spot is very brown and rather sharply defined, but in a warm moist place favourable to the rot the fungus grows very rapidly through the fruit, the limits of the affected tissue are ill-defined and the brown colour not so pronounced. This difference in the appearance of the rot will give a valuable indication of the suitability or otherwise of storage conditions. As the rot progresses further, the spot becomes much darker in colour, and pimply black spots appear in it just under the skin. (Fig. 20.) Later these pustules break through the skin, and spores are extruded from them in long tendrils, which, however, are not evident if enough water is present to moisten them. The infection is spread by these spores to other fruits by rain and wind or, in the case of stored apples, by handling and by air currents. The rot is also spread a good deal in barrels, boxes, and heaps by growth of the fungus from one fruit to another in contact with it.

Fig. 20
An apple destroyed by Black Rot. The tiny black pimples with which it is covered are filled with spores.

On the leaves of the apple tree the fungus forms brown, nearly circular spots, with definite borders and often showing concentric markings. In these spots later on there may appear also black spore pustules similar to those of the fruit. The attack on the leaves is not of great importance except in so far as it concerns the spread of the disease, for it rarely occurs in sufficient amount on the leaves to cause appreciable injury.

The fungus is frequently met with, however, on limbs and twigs of apples and pears, and seems to be more common on these than on the leaves. Dead and dying limbs on weakly branches are often seen to be studded with the small black pycnidia (fig. 23), and Sun Scald is frequently followed by an attack of Black Rot. Cankers are sometimes found, which are apparently due to it (fig. 21), especially in neglected orchards. Sometimes these cankers are superficial and cause merely a roughening of the bark without penetrating to the cambium below. In other cases a deep canker results, involving the death of the cambium over a considerable area. According to the writer's observations, such severe cankers arise most frequently where the fungus has gained entrance through a wound or by way of a dead twig or branch.

The means that might be used with profit in lessening losses from this and other similar rots are mainly preventive. There can be no doubt that on the ground under an apple tree, there are countless spores of the fungus which have fallen from twigs and cankers on the tree or been washed and spattered by the rain from old rotten fruits.

Fig. 21 Fig. 22

21. Black Rot canker on an apple limb.
22. Apple branches affected by small Black Rot cankers.

Fig. 23
Black Rot Fungus on apple twigs.

When an apple falls on such a surface, the chances that it will escape infection are not very great, especially if it has acquired the usual bruise or two in its descent. Even if picked up immediately, before rot has developed, the spores are likely to adhere to it and may bring about rot later in storage.

It is highly probable that the excess of lime sulphur which falls to the ground when a tree is sprayed, is not entirely wasted as one might think, but does an important service in destroying vast numbers of the spores of this and other rot fungi, and thus helps materially to protect the crop. Other means that naturally suggest themselves are: hand picking as far as possible; removing fallen fruit before rot has a chance to develop; care in pruning to remove all cankers and dead twigs infested by the fungus; storage of fruit in a dry, cool place with plenty of ventilation; destruction of affected fruit either by burning or burial; thorough covering of the trunk and limbs by some cleansing spray to destroy stray spores and to kill the fungus as far as possible in cankers and sun scald areas.

In parts of the United States where Black Rot has been a serious pest on apples on the tree, it has been found that two applications of Bordeaux mixture gave satisfactory control. In Ontario, however, if sufficient care is taken to prevent infection by the measures suggested above, it is possible that in most cases special spraying of this nature will not be needed.

Brown Rot (*Sclerotinia fructigena* (Pers.) Schroet).

The Brown Rot fungus, which is so prevalent on plums and cherries, also attacks the apple to some extent. It is typically a ripe rot, and with us is fortunately not so abundant on apples as it appears to be in regions farther south. The fungus gains entrance through a break of some kind in the skin, and a very deep rot spot develops. At first the tissue remains more or less firm and does not shrink so as to cause a depression in the surface. Under warm and moist conditions the familiar greyish-brown spore-bearing pustules are produced on the surface. Later on the apple shrinks up and wrinkles and becomes very black and tough within on account of the formation of sclerotial masses in the flesh. No especial control measures are recommended beyond care in picking and handling the fruit and cleanliness in storing it, so as to avoid punctures or bruises on the one hand and contamination from the spores of rotted fruits on the other.

Crown Gall, Root Gall (*Pseudomonas tumefaciens* Erw. Smith and Townsend).

Crown or Root Gall has been the subject of a great deal of inquiry for many years, but it is only in comparatively recent times that satisfactory knowledge as to its cause has been obtained. According to the work of Smith, Townsend, Hedgecock, and others, it is due to a bacterium which has been isolated from the galls themselves and studied with considerable care. Large numbers of cross-inoculation experiments made with cultures taken from galls occurring on apple, pear, peach, plum, cherry, prune, grape, raspberry, blackberry, walnut, chestnut, and rose, demonstrate that the galls on all these plants are of similar origin and are due either to the organism of the apple gall or to very closely related biological forms. It has also been clearly shown that the hard gall of apple, soft gall of peach, and hairy root of apple are all forms of the same disease. Besides those on the plants mentioned above, galls of like nature have been found naturally, or have been produced by inoculation, on a large number of other garden plants, wild plants, and weeds.

These galls are usually found about the roots or crown of the affected plant as swollen tumerous growths. It has been shown by Erwin Smith that the texture of the gall is determined by the region where infection occurs. An infection in a soft growing tissue results in a so-called soft gall, whereas a deeper infection involving woody tissues causes a hard gall. The former will usually disappear in a short time, but the latter may last for years. The Hairy Root with which young apple trees are sometimes affected is, as stated before, only another form of the disease. In this case, instead of the normal branching of the root whereby it becomes gradually divided up into smaller and smaller roots, this main root bears directly clumps or masses of fine rootlets. An aerial form of Crown Gall on the trunk and limbs of trees is occasionally met with.

The size of galls on various plants varies considerably. On raspberries it usually grows about as large as marbles, but much larger ones occur on the apple, pear, and peach. Fig. 63, in which the size is indicated by a rule, is from a peach root. Where the gall is formed on the main roots, or especailly on the crown of a young tree, it is extremely damaging to the growth and vigour of the tree.

Infection takes place from the bacteria liberated from old galls in the soil, and these usually enter their host by means of a wound of some kind. The working of the land carries the infection from plant to plant, and cultivating tools and implements are responsible in a great many cases for the wound whereby the organism becomes established. The three galls shown in fig. 62 all occur at the edge of a wound evidently made by some tool. It is a matter of observation that cultivated plants are more subject to galls than wild ones, and that young plants are especially susceptible. This explains to some extent the prevalence of the disease on nursery stock.

Great care is needed, therefore, in the growing of nursery trees, since they are the most important means of spreading the disease. Under existing conditions, where several series of young trees are grown in succession on the same piece of land, the disease if present in the soil has every chance of being spread in a most dangerous way.

A great many people seem to think that, when planting out young trees, they can get rid of the trouble by cutting off such galls as are then present. Such an idea is quite erroneous, however, for it has been shown that from an active gall the bacteria make their way in strands to other parts of the plant, where they may give rise to other galls. This method of spreading makes it plain that removal of the galls cannot be depended on to rid the plant of disease, since the infection strands still remain to form new galls elsewhere.

There is little evidence at hand regarding the length of time that bacteria from galls will remain alive in the soil, but it is certain that susceptible plants set in soil where Crown Gall recently existed readily contract the disease. Such a state of affairs is often brought about when raspberries are grown among, or follow, peaches which are affected by the galls. Many men have had their raspberry fields ruined by root galls, the introduction of which they attribute to planting out peach trees affected by the disease.

As far as our present knowledge extends, Crown Gall does not appear to be a very serious factor in the adult apple orchard. Several extensive experiments have been recorded by the American Association of Nurserymen in which blocks of young apple trees affected by galls were planted along with similar trees free from disease. Some of these were dug up from time to time for examination of the roots and the records of these examinations are assuring. Not only did the galls seem to disappear after a time in many instances, but the affected trees grew as well and were just as vigorous as others free from galls. This was true even in cases where the galls had persisted or new ones had formed.

These results have been supported by a vast number of individual experiments and observations, and the general opinion among apple growers at present is that the injury from this source has been over-emphasized.

There are several reasons, however, why it is unwise to plant out trees affected by root galls. In the first place, there can be no doubt that the galls are actually injurious to some degree, and especially to young trees, and this injury is very evident where the gall is large and on the crown. Such trees are retarded in growth, weakened in vigour, and often die in a short time. Even if they do survive, they are set back considerably. A second reason concerns the after-effects of galls. When one of these decays, it leaves in the surface an inviting opening for the entrance of rot fungi. This phase of the question may be of little importance where galls on the smaller roots are concerned, but when the opening occurs in such a vital part of the tree as the crown, it is a very serious matter for the tree.

There is a still more important reason for rejecting trees with Crown Gall, and one that ought not to be ignored. It is the danger of introducing to the farm a bacterial pest known to be capable of infecting a large number of other plants, some of them severely, and for which there is as yet no known remedy.

It should, therefore, be the invariable practice in planting out young orchards to discard and burn everything affected in any degree by Crown Gall or Hairy Root, and it would be further advisable to assure oneself that the land on which these trees had been grown was also free from the organism.

Fly Speck and Sooty Blotch [*Leptothyrium pomi (Mont. and Fr.) Sacc.*]

These troubles are apt to occur in damp seasons or in moist, wet situations. The two are usually found in association, and are held to be due to the same fungus. Both are superficial, and the chief injury of the fruit is to its appearance. The Fly Speck, as its name implies, occurs in the form of a small spot, hard, black, shining, and about the size of a pin's head. The number of these present on an apple varies from a very

Fig. 24
Sooty Blotch of apples.

few widely scattered specks, scarcely noticeable except by close examination, to large numbers set at close intervals over a considerable portion of the fruit. The Sooty Blotch or Sooty Mold, as it is sometimes called, forms a more or less circular patch of radiating threads, the colour of which is a dull, brownish-black. (Fig. 24.) Aside from damp situations or wet seasons, the disease is rarely important, especially where spraying is practised. Bordeaux mixture has been recommended in favour of self-boiled lime-sulphur, where it is desired to treat these troubles separately or in conjunction with Apple Scab.

Irregular Apples.

A number of cases of irregular or deformed apples have been met with in this district during the past two years. These irregularities seem to be of two distinct kinds. In one class, which is the more common, the apples remain small, ripen late, and are lumpy and deformed. Nearly all the apples on a tree may be affected, or only a few, and they may be present one year and not the next. They have the normal

number of seed cavities, but develop few if any seeds. Often they are found hanging in bunches together on a limb in the fall after all the others have fallen. In this case, the work of aphids early in the spring is assigned as the cause. The trouble has been met with most frequently on the Northern Spy, though it is found on other varieties as well.

In the other case, the apples are lobed or divided by fissures running from calyx to stem (see fig. 25) and are further characterized by their excessive number of seed cavities and the imperfect union of these with the calyx, i.e., the rest of the apple.

They have usually fewer seeds than normal, but these are not so evidently absent as in the other case. Nearly all the apples on a tree are more or less affected, and the

Fig. 25
Irregular apples.

trouble persists year after year on the same tree, though others nearby are not affected. It is probable that the irregularity in this case must be attributed to some derangement of the growing point or, in other words, the cause is physiological. No remedy can be suggested.

Nectria Canker [*Nectria cinnabarina* (Tode) Fr., and *N. ditissima* Tul.]

The coral fungus, as it is sometimes called, is common on dead twigs everywhere, and becomes parasitic in certain cases. It is often met with on currant canes, on branches and twigs of horse chestnut, and it is occasionally found on apple shoots. In the latter case, it either enters by way of a wound or establishes itself in a dead or dying shoot.

The European species (*N. ditissima*) has been recorded as forming cankers on the limbs of apple trees in America, but so far the writer has not met with it in Ontario

orchards. The native species, *N. cinnabarina,* is, as above mentioned, common on twigs, and occurs occasionally on the apple, but no case connecting it with limb cankers has been observed.

The fungus is conspicuous, breaking through the bark of affected twigs in brilliant pink or reddish spore-bearing pustules about the size of a match-head or smaller. Those are followed later by another stage of the fungus, which becomes reddish-brown in age.

Pink Rot (*Cephalothecium roseum* Cda.).

A rot of stored apples has been met with several times, usually on Snow apples, and always succeeding scab. The fungus appears to gain entrance in the cracks caused

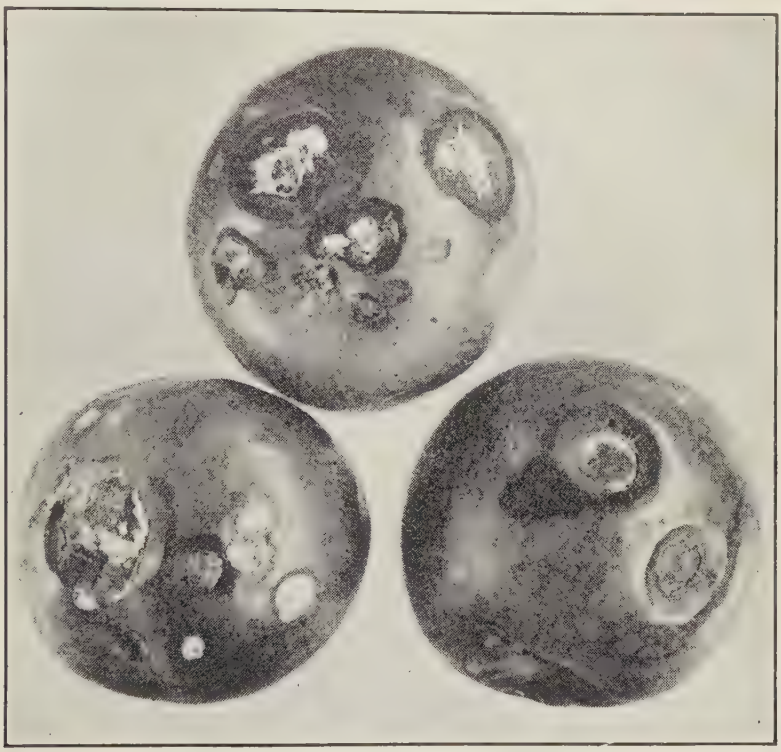


Fig. 26
Pink Rot on snow apple. The Rot is seen to be spreading from the scab spots where it gained entrance.

by the scab, and then produces a rather slow-growing rot spot from this point (see fig. 26). If the apples have been kept in a moist place, the fungus appears externally on the spot, particularly around the scab. It forms a delicate growth, white for the most part, though it may have at times a pink or rosy tinge as the name indicates. As the fungus is particularly bad following scab, avoidance of scab is the first requisite in dealing with this rot, and since it grows best under warm, moist conditions, apples liable to bear it should be stored in a cool, dry, well-ventilated place. Greening Fameuse, and King are among the more susceptible varieties.

RUST (*Gymnosporangium macropus* Lk. and *G. globosum* Farl.).

The Apple Rust is scarcely ever serious on the apple in this part of Ontario. It is peculiar in that it has two stages in its life-history, each on a different host. The early spring stage occurs on the juniper or red cedar, and the summer stage of these and other related species is found on apple, pear, quince, hawthorn, and other related plants of the Rose family. (See Quince Rust, p. 41.) In the case of the apple the leaves and sometimes the fruits are affected, the rust forming small yellowish areas from which protrude later on little finger-like orange-coloured sacs, which bear the spores. It is noteworthy that in other parts of Ontario where red cedar does not occur the rust is unknown, which indicates that the method of controlling the rust is to get rid of the red cedar in the vicinity. This will often necessitate the co-operation of neighbouring owners, since the spores can be carried in spring by the wind for a couple of miles or more. Bordeaux mixture applied at the time of infection (early in May) is said to greatly lessen the disease.

Fig 27
Apple Scab on leaves.

SCAB (*Venturia inaequalis* (Cke.) Aderh.).

This is easily the worst fungus disease with which the apple orchardist has to contend, and its attacks are damaging to his crop in a number of ways. In the first place the amount of the crop is lessened, both by the direct effect of the fungus on the fruit itself and indirectly by its effect on the leaves, for an attack of scab greatly reduces their food-forming power and prevents them from feeding the apple up to its maximum size. The loss sustained by lessening of the crop varies, of course, according to the extent of infection, but may reach as high as 50 per cent or even more. Besides this shortage in the number of barrels produced, the quality of such apples is always very inferior and their appearance far from inviting. From both points of view scabby apples are at a disadvantage when put on the market. Those buyers who judge their apples by quality and flavour know that underneath scab the tissue of the fruit is hard, unripened, bitter in taste and far below the best standard of quality. On the other hand, a large number of consumers, especially in towns and cities, buy their apples on appearance alone, having little regard to the differences in quality and flavour of the several varieties. In either case, the buyer will pass by the scabbed fruit wherever

possible, so that it can only enter the market in times of scarcity or by virtue of a very low price. The ready market and the high price are for clean fruit. Still another disadvantage in scabby apples is their liability to rot in storage (see p. 29.).

The familiar circular scab spots on the fruit scarcely need description. They begin as olive-green patches, which later increase in size and sometimes acquire a brownish tinge. The skin above them cracks and breaks up, giving a rough scurfy appearance to the surface of the spot. The fungus does not penetrate the flesh of the apple, but lives entirely on the surface just under the skin. Yet its presence is very damaging, especially if several spots lie close together or coalesce. In such cases, the whole of the fruit or one side of it has its growth retarded, and a small or deformed apple is the result. When a fruit is badly attacked in the early stages of growth, it may die and fall off. In any case, no matter how small the scab spots or how few of them are present, they are definitely injurious to the fruit, for the tissue beneath for a considerable radius is hard, bitter, unripened, and distinctly inferior in flavour. When a bad attack of scab exists, the inequality of growth that results often brings about unsightly cracks in the apple. Such fruits do not keep well.

On the leaves, and sometimes on the twigs, the fungus occurs as olive-brown patches (fig. 27). These may become so large as to involve almost the whole of the leaf, and cause considerable distortion. Spores which spread the disease are produced on both leaves and fruit, and if the season is favourable for the growth of the fungus, the spring or first infection is added to in this way. The disease spreads more rapidly when the weather is cool and moist, as is usually the case in spring, than in the dry, hot periods of summer. However, exceptional years may occur, as in 1913, when late in the season the disease may become quite active. The fungus winters over in the leaves on the discarded fruit and possibly on twigs. For this reason it is advisable to destroy in some way all fallen leaves and fruit, the most obvious method being to plough them under in the fall.

As regards susceptibility to scab, the Snow is most affected, also the Spitzenberg, Greening, and Northern Spy to a somewhat lesser extent, while Russets are the most resistant.

Scab can be controlled, except in exceptional years, such as above mentioned, by spraying as follows:—

1. A dormant or cleansing spray in spring given shortly before the buds burst, using lime-sulphur testing 1·030 sp. gr. (or commercial lime-sulphur concentrate diluted 1 to 8). This application must be very thorough, for it is the means used to obtain a general cleaning up of the tree. It is, in fact, in the nature of a real spring house cleaning.

2. A second spraying just before the blossoms open. Use lime-sulphur testing 1·010 sp. gr.; commercial lime-sulphur concentrate diluted 1 to 30 or 35; or Bordeaux mixture 4:4:40. It is usually desirable at this time to add a poison for insects, for which purpose arsenate of lead is recommended, used at the rate of 2 or 3 pounds for 40 gallons of spray.

3. A third application just after the petals have fallen, and before the calyces close. Use lime-sulphur testing 1·008 sp. gr., or commercial lime-sulphur concentrate diluted 1 to 35 or 40, or Bordeaux as above. Arsenate of lead should be added here as well. If this spray is applied while the blossoms are still being visited by bees there is some danger of their being poisoned. On the other hand the effectiveness of the lead arsenate depends on its being sprayed into the open calyx or blossom end of the young fruit. When the calyces have closed the value of the poison is very small.

4. When wet weather succeeds the third application it may be necessary to give a fourth about ten days later, using any of the materials mentioned for No. 3, but without the lead arsenate.

The spraying should always be supplemented by other means of keeping down infection, among which the destruction of the old leaves and fruit is particularly important.

TWIG BLIGHT, FIRE BLIGHT, PEAR BLIGHT.

(*Bacillus amylovorus* (Burr.) De Toni).

The blight organism which causes this disease is identical with that occurring on the pear. In the case of apple its ravages are not so serious as on pears, but at times it occasions considerable damage, especially in old neglected orchards. Its chief effect on the apple is as a twig or blossom blight. Apparently the infection is carried from blossom to blossom by insects, and such a large amount of infection is spread in this way that a badly attacked tree looks as if it had been scorched by fire. Besides the destruction of blossoms and occasionly young fruit, there is danger, as in the

Fig. 28 Fig. 29

Apple trees killed by winter. In fig. 28 the roots are exposed to show that though the trunk was killed the roots were not hurt.

pear, of the blight organism making its way into the trunk or larger limbs by way of water shoots, the tender growth of which is especially susceptible to infection. Serious cankers may be formed in this way, and large limbs destroyed.

As in the case of the pear, preventive measures should be adopted. Although the organism is for the most part killed by the winter, yet there are some branches in which it survives and from these, infection is renewed the following spring. All blighted parts, therefore, should be cut out and burned during the fall or winter, and frequent examinations should be made during the summer to prevent the organism from reaching the limbs and trunks by way of twigs or shoots. The same precautions should be observed in cutting out affected parts, as in the case of the pear. See p. 36 where the subject is more fully dealt with.

Water Core (Physiological).

According to a recent article published by a United States pathologist, Water Core in apples is not caused by any parasite but is a result of special conditions of growth, soil, and climate, which induce a high sap pressure at a time when leaf evaporation is low. This pressure brings about a "flooding," so to speak, of the tissue of the apple. The following factors are mentioned as contributing to the trouble: A vigorous and healthy tree, especially one just coming into bearing; abundance of soil water; high temperature during the day followed by cool nights. At night the atmosphere reaches the saturation point while the soil is still warm, and this warmth produces an upward flow of sap, which is not relieved by evaporation; this congestion is emphasized if the leaf surface has been reduced by pruning, frost, or defoliation by insects and fungi. Apples suffering severely from Water Core are liable to rot in storage, but those in which the water does not flood the seed cavities may recover entirely, the surplus fluid being apparently taken up by absorption or evaporation.

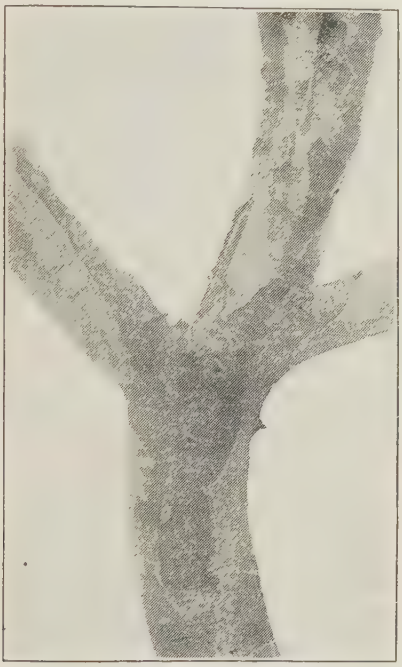


Fig. 30
Young Baldwin tree with areas of the trunk and crotches killed by winter injury.

Winter Injury.

A general discussion of this question is given on p. 16. The form of winter injury that are commonly found on the apple are as follows:—

(1) *Trunk or Sun Scald.*—This may affect one side of the tree only, as noted before, but in some cases the injury is extensive and involves so much of the trunk that the tree dies. The two apple trees shown in figs. 28 and 29 were thus destroyed. In fig. 28 the roots are laid bare and are seen to be quite unharmed, but the trunks of both trees, as well as those of 80 per cent of the whole orchard, were either killed wholly round, or else so badly damaged that they died in a year or two. Where the injury was only partial it was found, as usual, on the southern exposure.

(2) *Limb Scald.*—A not uncommon phase of Sun Scald occurs on apple limbs, especially on trees that have been "dehorned." The upper surfaces of the large limbs are killed in long strips on such trees and a long open wound results.

(3) *Collar Rot* is frequently met with in apple trees. Where only part of the trunk is damaged, the tree, or at least the injured side of it, will bear small yellowish leaves.

(4) A peculiar case of winter injury, illustrated in fig. 30, has been met with on several occasions. The damage was confined to the crotches and adjacent parts of the limbs and trunk. Both bark and wood cambium were destroyed in the areas shown, and where girdling was complete the tree or a part of it died.

PEAR.

Anthracnose or Black Spot, Leaf Spot [*Fabraea maculata* (Lev.) Atk.].

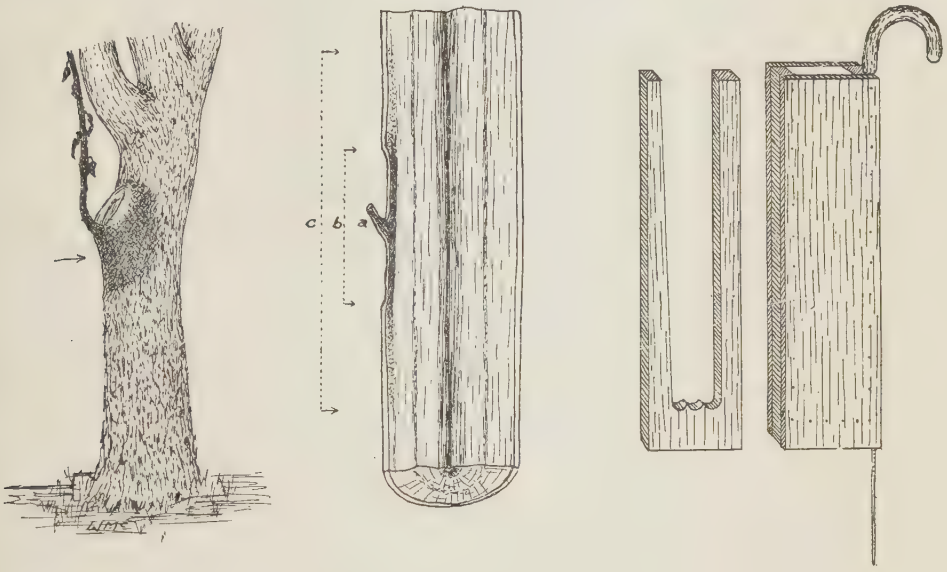
This leaf and fruit spot occurs on the pear as well as on the quince. It is not, however, a very serious trouble on either leaf or fruit. On the leaf it forms a spot which is reddish at first but which subsequently becomes darker, and it may be distinguished from the more common Leaf Spot (*Septoria piricola*) by being rounder and somewhat larger than the latter. On the fruit black spots are formed which have much the effect of Scab. As in the case of the quince, it is rarely present where infection is lessened by the destruction of old leaves and by the use of a cleansing spray in spring.

Blight, Fire Blight, Body Blight, Twig Blight, Blossom Blight (*Bacillus amylovorus* (Burr.) De Toni.).

This disease has been a source of very serious injury to the pear orchards of the Niagara district, and is by far the most important disease of this fruit. On account of its ravages, there has been a great reduction in the number of pears planted in recent years, especially of the more susceptible varieties, and some growers have almost given up pears as a profitable crop, notwithstanding the fact that they usually command good prices.

The organism producing the disease has been well studied by various pathologists, and numerous experiments have established the main features of its life history, as well as the means to be used in controlling it. The bacillus, though killed for the most part during winter, survives in some few twigs and branches. In early spring it multiplies again very rapidly in these branches, from which during moist weather there may be seen exuding drops of a sweetish liquid. Insects seem to be very fond of this liquid, and as it is literally swarming with Blight bacilli, the infection is very readily carried to other parts of the tree. Insects which suck the juices of plants may easily introduce the bacili into their punctures or into the sap about fresh wounds. Perhaps the most important phase of spring infection, however, arises when the organism is carried by insects to the blossoms, in the nectar of which it multiplies with great rapidity. Nectar-loving insects as they pass from flower to flower, transfer the infection, and the industrious bee which visits many thousands of flowers in a day is no doubt very instrumental in this work. Thus from a small beginning a whole orchard becomes infected in a short time, and the production of such a large number of infections almost simultaneously could scarcely be accomplished in a more effective way. The bacillus multiplies rapidly in the nectar of the blossoms and penetrating into the tissue of the blossom itself destroys it. Very often it extends its growth on into the twigs as well, and the leaves borne on these blacken and die suddenly over large parts of the tree at the same time. The appearance of a tree stricken in this way is similar to that caused by burning brush beside it, and has given rise to the name of "Fire Blight."

In most cases the organism dies in the twig and no further damage is done. But at times it establishes itself in the inner bark or cambium of the twig and grows back into the branch, progressing rapidly and killing the branch as it goes. Its advance can be marked by the shrinking and drying of the bark over the affected area. Large limbs are often girdled by an infection which has crept in on one of the smaller branches, and often trees of large size are reduced by successive stages to one or two small branches. The effects of Blight are extremely disastrous when the disease occurs on a water sprout and is led by it directly into the main stem or larger limbs (fig. 31). The soft succulent growth of these shoots seem to be especially susceptible to infection, and the infection passes along it at a very quick rate. An infection from such a source may girdle a large limb or even the whole trunk in the course of a few days. Such shoots should be carefully looked for during the growing season and destroyed before the bacterial growth within can reach the more vital parts of the tree.



Pear Blight.

31. Trunk of pear showing a common and dangerous phase of Blight attack. The Blight has attacked a water shoot growing from near a pruning wound, has travelled down the shoot, and has destroyed the tissue of the trunk indicated by the darkened area.

32. Diagrammatical representation of a Blighted Pear limb. The bacteria, having entered by way of the twig (a), have spread both up and down the limb. The area shown by (b) is killed, as is externally evident by the depressed bark. The bacteria, however, are present beyond this area, and their progress is shown by the dots in the area included in (c). Beyond the depressed area (b) there is no evidence of their presence externally, hence the extreme importance of cutting well below the external limits of Blight.

33. Simple apparatus for sterilizing the pruning saw used in treatment of Blight. It requires a comparatively small amount of liquid and is light and convenient to use. The old umbrella rod fastened to one edge with nails or staples is an excellent handle. The lower end may be stuck in the ground to hold the utensil upright while the crook is convenient for carrying it or hanging it on a limb.

In some cases, while the bark of the pear remains green and sappy, the Blight organism enters it by way of twigs, insect punctures, or small wounds, and kills a larger or smaller area of the outer bark without injuring the living cambium underneath. The organism finally dies out in these areas, leaving a depressed and darkened region in the bark. Since the Black Rot fungus has a similar habit in this respect, and is often found in such dead areas, it is possible that at least in some cases it and not the Blight bacillus is the causal parasite.

Moreover, the natural dying of the outer bark consequent on the formation of a new bark-forming layer below, seems at times to take place in isolated areas, so that similar dead depressions are formed. It would scarcely be safe, therefore, in the absence of cultural proof to attribute all these superficial bark depressions to the work of the Blight organism.

It is evident that the most successful point of attack for this disease is in the winter or early spring, when the wood is dormant and the bacilli fewest in number. At this time the orchard should be carefully gone over and every bit of diseased wood cut off and burned. Unless this is done very thoroughly the results are likely to be unsatisfactory, since such a very small area of diseased tissue can so readily start infection again in the spring. In the late fall, while the blackened leaves on the dead branches are still conspicuous, this work may be done to advantage, and as the leaves on blighted limbs usually remain on them long after ordinary leaf fall, considerable help is afforded later on in the season in locating the affected parts. Large numbers of diseased limbs and twigs, however, will occur throughout the orchard which have no such indicator, and patience and sharp sight must be depended on to locate them. The difficulty in finding all the affected twigs and branches makes it advisable to do this work only when the light is good. It must further be borne in mind that the Pear Blight organism also attacks the apple, quince, wild crab, mountain ash, and hawthorn, and, therefore, care must be taken to see that none of these within half a mile of the orchard is allowed to become a source of infection.

Besides this fall or winter pruning of the blighted limbs and branches, it will be necessary to go over the trees every little while during the summer, especially during the season when the disease is most active, and cut out and burn the affected parts, taking especial care to not miss anything which is in danger of carrying the disease into the trunk or larger limbs. In all the pruning operations it is extremely important to cut well below the diseased part, both in order to remove the whole of the infected limb and to avoid cutting into the tissue containing the bacilli, which would then be carried on the saw or knife to the next cut. In the fall or late summer, when growth is slower and the sap less abundant, the shrivelling or drying of the bark may almost keep pace with the progress of the bacteria within, so that by cutting a couple of inches below the margin of shrunken bark, safety on both points would be assured. But in spring and summer, when the tissues are soft and full of water, the disease advances so rapidly that the organism may have worked its way a long distance down the branch before the external shrinking of the bark becomes evident (fig. 32). The presence of the parasite in the soft bark or cambium causes a reddish discoloration or a browning of the wood, and this indication may often be found 6 or 8 inches below the apparent limits of progress, as shown externally. Hence the necessity of cutting well below the outward indications of blight is evident. On account of this difficulty in determining the real limits of infection, the pruner is sure to cut into bactera-bearing tissue from time to time, when of course the extremely minute organisms adhere to the saw and knife and are carried to the next cut. It is therefore necessary to sterilize the tool after each cut by dipping it in a solution of corrosive sublimate or formalin (see p. 70). A handy vessel in which to sterilize the saw, and which can be made by any one, is shown in fig. 33.

In connection with the question of sterilization, it has been found that sunlight is a very effective agent for this purpose, and that the Blight organism on infected tools is destroyed by an exposure of fifteen or twenty minutes to the sun's rays.

While all pear varieties are attacked by Blight, there are some which are far less susceptible than others. Among these the Kieffer is notable, while the Anjou, Angouleme, and Seckel are to some extent resistant also. The Bartlett, Clapp, and Flemish Beauty are among the more susceptible varieties.

It has been noted that pear orchards kept in sod are not so liable to blight injury as others kept in a cultivated state. Such orchards, however, cannot be readily fertilized, and dry out so much that their crop is usually inferior and small. It is evi-

dent that whatever immunity they possess is due to lack of water in the tissues, and to their slower hardier growth. Many growers claim that a compromise between close cultivation and sod gives fairly satisfactory results. A strip of sod is left along the rows and the land between is kept cultivated. Fertilizers can be applied on this land, and a good deal of moisture conserved by working it into a mulch. The sod, on the other hand, retards the growth of the tree and keeps it sufficiently dry to produce unfavourable conditions for blight development.

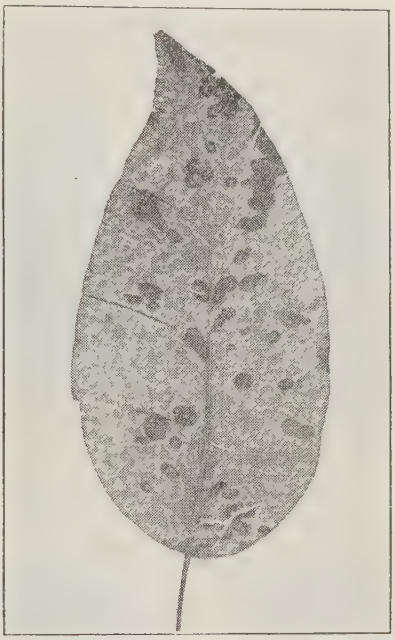


Fig. 34
Pear Leaf Spot.

Collar Rot—Crown Rot.

The form of winter injury known as "Crown" or "Collar Rot" seems to be quite prevalent on the pear, especially on wet soils or soils lacking in humus. The injury is found just below the surface of the ground, and involves the crown and part of the trunk or the crown and roots. The bark on these is found in a brown dead condition, having been killed during the preceding winter. (See under Winter Injury, p. 16.) Such trees will have small unhealthy leaves, subject to leaf diseases and drought injury. They suffer frequently from sunburn at the tips and edges, apparently because of inadequate water supply. If the summer is very dry the whole tree may die outright before fall, when the girdling is complete, and in any case such trees will not survive the next winter. Trees in which the girdling is not complete, but which still retain some living connection with their roots, are conspicuous among their healthy fellows on account of small-sized yellowish leaves or leaves with a reddish tint. Reddish discoloration of pear leaves is not always a sign of Collar Rot, however, for on certain clay soils the leaves normally assume this colour in fall. Also certain individual trees may have bronzed foliage without having suffered any apparent injury.

Leaf Spot (*Septoria pyricola* Desm.).

The attacks of this disease are mostly confined to the leaves, which are so weakened by it when severe that the vigour of the tree is seriously impaired, and there is a large

deficiency in the food stored up for next year's growth and crop production. The spot produced is more or less angular in outline, and usually small. On younger leaves, it is characterized by an ashen grey centre surrounded by a ring of brown or black. Toward the outside, this ring shades off into a purplish fringe. In older leaves, the last two features are less clearly marked, but there may appear in the dead portion

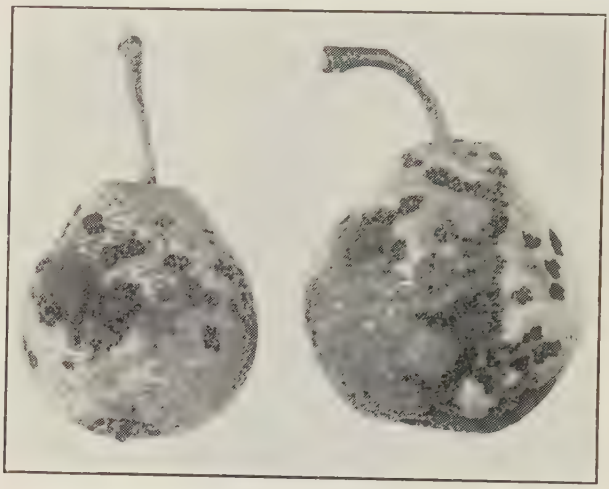


Fig. 35
Pears suffering from a bad attack of Scab.

Fig. 36
Three Flemish Beauty Pears cracked open as a result of hardening of the skin by scab. Practically all the fruit on this tree was thus cracked.

several minute black spore-bearing bodies (pycnidia) from which the spores may sometimes be seen extruding in long finger-like masses. Like most other leaf-spot diseases the Pear Leaf Spot is less severe on well cultivated varieties, especially if these have been given the customary cleansing spray of lime sulphur in the spring. Even under these conditions, however, it is liable to occur on certain susceptible varieties such as

the Anjou, Seckel, and Bartlett. The Kieffer is little troubled, and Flemish Beauty, Duchess, and Winter Nelis are more or less resistant also. Nursery trees and orchard trees which from any cause have their vitality lowered, are both subject to attacks of the disease. The lime sulphur or Bordeaux sprays recommended for Pear Scab will control the Leaf Spot also.

Scab (*Venturia pirina* Aderh.).

What has been said about the Apple Scab may be considered as applying to this disease as well, since the fungi causing both are almost identical as far as appearance and life-history are concerned. Like the Apple Scab it is superficial on the fruit, where it forms circular greenish or brown spots. Often these spots run together to form dark irregular patches, which may cover a considerable part of the surface (fig. 35). Under these patches, the flesh remains green and hard, and grows much slower than in unaffected regions. There is consequently a good deal of distortion of the fruit, and frequently cracks arise because of the strains produced by unequal development (fig. 36). On the leaves and twigs, the fungus has much the same effect as on the apple. Olive or brownish patches occur on the leaves often with distortion of its surface. The twigs are attacked in small areas, which are roughened by the fungus. The latter is perennial in these spots.

Pear Scab can be controlled by lime-sulphur readily enough on such varieties as Bartlett, Kieffer, and Le Conte, which are less susceptible to its attacks, but it is rather more difficult to protect Seckel, Duchess, Anjou, and Flemish Beauty. However, if the three sprayings recommended for Apple Scab are used, or Bordeaux mixture applied in the same way, the results ought to be quite satisfactory. Such treatment must be helped out by burning or ploughing under the old leaves and fruit in the fall.

QUINCE.

Black Rot (*Sphaeropsis Malorum* Pk.).

As in the case of the apple, the Black Rot causes on quince a rot of the fruit, a leaf spot, twig blight, and limb cankers. Its chief effect, however, is a fruit rot, and what is said regarding means of prevention and treatment under the apple will apply here (see p. 22).

Blight, Fire Blight (*Bacillus amylovorus* Erw. Smith and Townsend).

Along with the apple and pear, the quince is subject to attacks of the Blight organism; twigs and branches are sometimes killed in the same way as on these other hosts. The slow-growing, hardier wood of the quince, however, renders it somewhat less liable to infection than the pear. The same methods as regards prevention should be followed here as in all cases where the Blight occurs (se p. 32 and p. 34). It must be kept in mind that the same organism is the cause of the disease in all these cases, and that each may be a source of infection for the other.

Leaf Blight, Fruit Spot, Black Spot (*Fabraea maculata* (Lev.) Atk.).

On the leaves, this spot disease becomes serious at times, causing premature defoliation, thus reducing the vitality and vigour of the tree (fig. 37). The spot is at first small and more or less circular, with a reddish centre and dark brown border. Later on it becomes black, and small greyish pustules appear in it. A similar spot occurs on the fruit, and though it does not materially injure the fruit for use, it is very disfiguring and decreases the selling value. It has been demonstrated that Bor-

Fig. 37
Quince Leaf Spot.

Fig. 38
Rust on Hawthorn fruits.

Fig. 39
A rusted Quince fruit.

deaux mixture will control the disease. The first application should be made soon after the blossoms fall, and two or three others should follow at intervals of two weeks thereafter. The general spraying of all fruit trees with lime-sulphur in the spring before the buds burst tends to decrease the amount of Leaf Spot to a great extent, and it rarely causes appreciable damage in this neighbourhood where this practice is followed.

Rust (*Gymnosporangium clavipes* C. and P.).

Quince Rust is to be found occasionally on the leaves, but mostly on the fruit of the quince. It begins as a dark olive-green patch on the fruit, which may remain so small that the fruit develops almost normally or, on the other hand, it may increase so much that it involves the whole fruit, which becomes swollen and deformed in con-

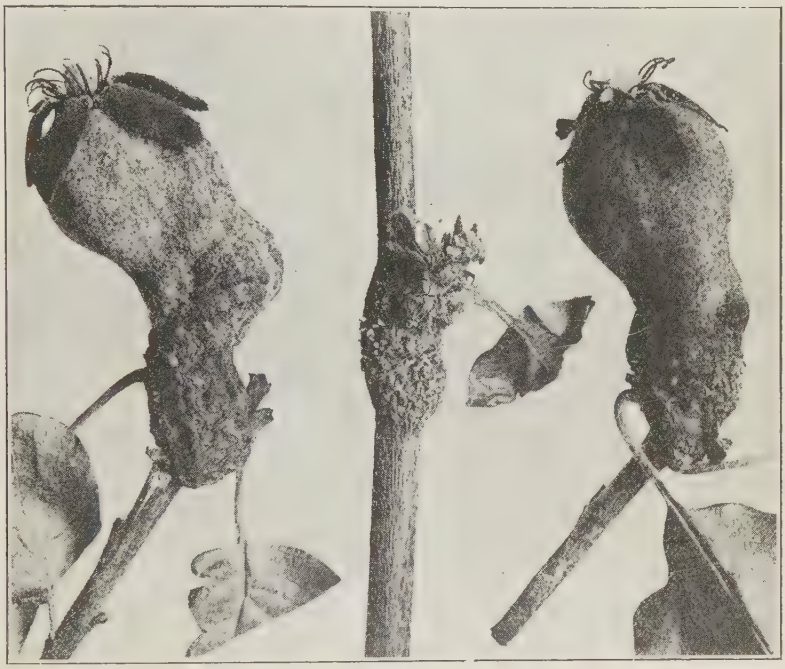


Fig. 40

Rust on shoots and fruit stems of Quince. The so-called "knots" are produced.

sequence. In this case, the fruit is rendered worthless, as the action of the fungus within the tissues is far-reaching and prevents proper ripening. Later on, there are protruded from this olive-green area small finger-like sacs filled with orange-coloured spores (fig. 39). On the leaves smaller spots are produced which also bear the orange spore-sacs. Ordinarily only a few fruits in the orchard are found to be affected, but occasionally it becomes a serious nuisance, as in a case reported from near St. Catharines in 1912, when every fruit in the orchard was attacked.

Sometimes the fruit stem, or even the twig on which the quince is borne, is involved in the infection, in which case a more or less woody knot is produced which may remain on the tree for several years afterwards (fig. 40). Such knot-like growths bear spores the first year, but die during the winter following. They are often mistaken for Black Knot, which is of course not found on the quince.

This Rust of Quinces is peculiar in that it has two stages in its life-history: one on the common red cedar or juniper, and the other on the quince fruit. The rust spores from the latter host are carried to the red cedar in late summer, and infection of it results in the production of swellings and knots on the twigs and branches. In early spring, during the latter part of April or the first of May, there are produced from these knots and swellings, conspicuous gelatinous growths, bright orange in colour, about as thick as a match and varying from one-quarter to three-quarters of an inch in length. These are particularly noticeable just after a rain, when they are swollen by the wet. Spores are produced by these growths, which are carried by the wind for considerable distances, and which infect again any trees of the quince lying in the way. Such infection will be greatest in the path of prevailing winds, and windy weather following damp periods at the time of spore production greatly favours the transfer of the fungus to its new host.

As noted in connection with this disease on the apple, there is no rust where the red cedar does not occur, as in parts of Ontario inland from the lakes. This indicates that the destruction of the red cedar would rid any neighbourhood of the disease. Since the spores may be carried more than a mile by the wind, such a method would only be practicable through the co-operation of a number of neighbouring owners, or by municipal control. The disease can also be materially lessened by lime sulphur or Bordeaux mixture applied at the time where infection from the red cedar is about to take place, which, as previously stated, is late in April or early in May.

APRICOT.

Very few apricot trees are grown in the Niagara peninsula or elsewhere in Ontario as the tree is scarcely hardy enough to be profitable. The following list of diseases is included, however, for the benefit of those who are growing or intend to plant this fruit. It will be noted that none of these diseases is peculiar to the apricot, hence their discussion may be referred to their more usual host.

Black Knot [*Plowrightia morbosa* (Schw.) Sacc.].—This is mentioned as a parasite of the apricot, but is probably not common. See cherry, p. 42, or plum, p. 47.)

Blight, Fire Blight (*Bacillus amylovorus* Erw. Smith & Townsend).—The Pear Blight is recorded as occurring on the apricot, but is unlikely to be general.

Brown Rot [*Sclerotinia fructigena* (Pers.) Schroet.]. This is a rot of the apricot as well as of the plum, cherry, and peach, which see, p. 49.

Crown Gall is also met with at times on this tree. See under apples, p. 25, for general discussion.

Cankers in all respects similar to those on peach trees are also found on the apricot. See p. 52.

Rust (*Puccinia pruni-spinosa* Pers.).—The plum is the usual host of this fungus, but it may attack the leaves of the apricot as well (p. 48).

Scab (*Cladosporium carpophilum* Thuem.).—A scab similar to that of the peach is found on the apricot fruit. Treatment, if necessary, will be the same as in the case of Peach Scab (p. 61).

CHERRY.

Black Knot (*Plowrightia morbosa* (Schw.) Sacc.).

The well-known dark and unsightly excresences caused by the Black Knot fungus occurs on a large number of plums and cherries, both native and cultivated (figs. 45, 46, 47). It is more commonly found on the cherry than on the plum, and is so serious on the former, when allowed to run unchecked, that an infested cherry orchard becomes worthless in a few years. The spores of the fungus are shed from the old knots in

winter or early spring, and when they find lodgment in a crack or wound of any kind, readily infect the limb. As they are apparently unable to cause infection through the uninjured bark, care should be taken in picking and pruning to avoid all injuries through which the fungus might gain entrance. This affected part swells and finally bursts the bark, exposing the abnormal tissue of the knot beneath. On the tissue thus exposed, spores are borne during the early part of summer, and its whole surface may be covered by the velvety olive-covered coating of these spores. Later on the spores fall off or are blown away, and the knot becomes hard and black. Toward the end of the summer, small black rounded pimples (*perithecia*) are formed on the surface, each of which is hollow and contains spores of another kind which ripen in late fall or winter.

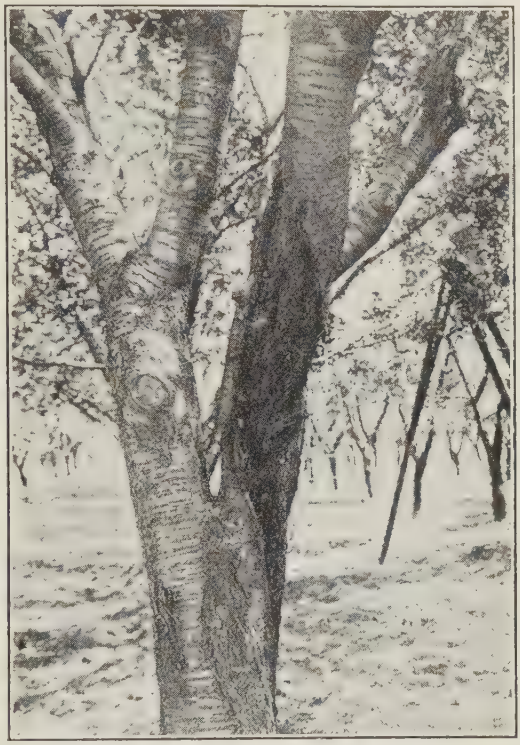


Fig. 41
A long open cankered wound on a sour cherry tree resulting from a Black Knot infection of a long frost crack.

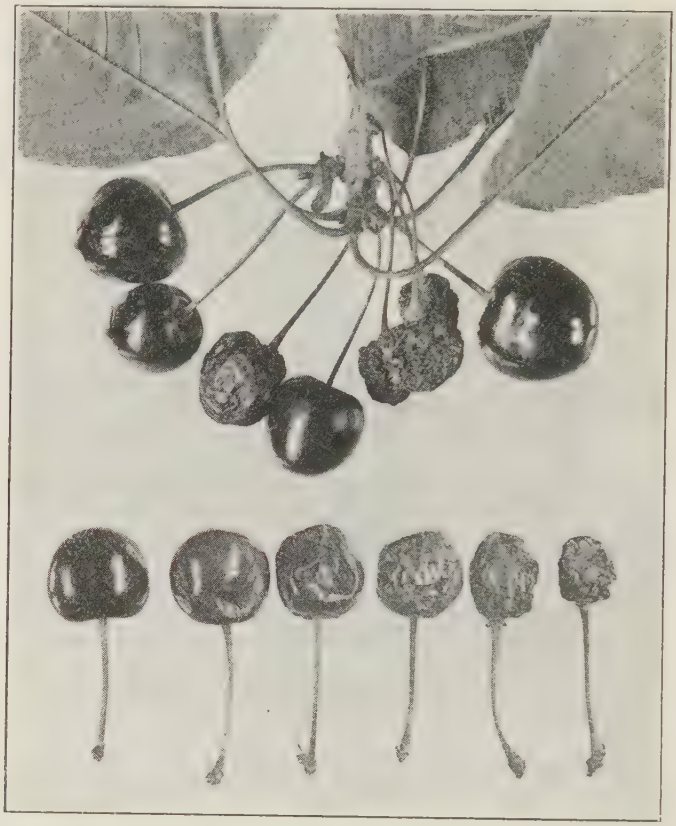
Usually the knot affects only one side of a twig or branch, and the fruit develops almost normally, but where a large section of the limb is affected so that sap flow is shut off, the limb dies. Knots occurring on smaller branches and twigs sometimes bring about considerable distortions of these, as illustrated in fig. 47.

Fortunately the control of this disease is not a serious matter. It has already been noted that the fungus occurs on several hosts, including wild plums and cherries, and that two crops of spores are produced in a knot, one in early summer and the other in late fall or winter. If to these two statements, there be added a third, viz., that the spores will ripen in a knot taken away from the tree just as well as on it, the main factors concerned in control are all before us.

The simplest and most effective means of dealing with Black Knot is in preventing the production of spores, which means the removal of knots before they reach the

spore-bearing stage. Since there are two such stages, it is only necessary to go over the trees in fall or winter and again in summer and cut out all knots that are to be found. Since the spores ripen on the brushpile as well as on the tree, all the material thus cut out should be burned immediately. If this procedure is followed, the disease can either be entirely eliminated from an orchard or reduced to a quite negligible quantity. The disease can be controlled as well by the use of Bordeaux mixture, and various chemicals, tars, paints, etc., have been used from time to time. Nothing has yet been found, however, which is so cheap, simple, and effective as the knife and saw. In the Niagara district, where large cherry orchards are common, the knot is almost unknown where this practice is followed.

42



43

42. Brown Rot on Sweet Cherries. The rotten fruits shrivel up into the characteristic "mummies."
43. A series of sweet cherries showing the progress of the Brown Rot.

There has recently been some discussion as to whether the Black Knot of choke cherry, that of cultivated cherry, and that of wild plum are not biological forms of the same fungus, all more or less confined to their respective hosts. Until this point can be definitely settled, it is wise as a matter of precaution to see that no wild plums or cherries affected with Black Knot are allowed to remain in existence near the cherry orchard.

Brown Rot.

See under plum (p. 49).

Cankers.

Canker areas somewhat resembling those of the peach are sometimes found on cherry trees. Some of these are true cankers of the peach type and others are apparently begun by persistent Black Knot on larger limbs or on the trunk. When the Black Knot finally dies out, the large dead area due to it remains as an open sore (fig. 41). Measures should be taken to prevent the establishment of Black Knot by keeping it cut out as soon as it appears. The cankers may usually be helped a good deal by cleaning out the dead wood and bark and painting them with any ordinary paint. See under peach (p. 52).

Crown Gall (*Pseudomonas tumefaciens,* Erw. Smith and Townsend).

The cherry, along with the apple, pear, peach, etc., is also a host for the Crown Gall organism. The same stringent measures should be observed here as in the case of the other hosts, in order to prevent the introduction and spread of this parasite. The reader is referred to the discussion under the apple (p. 25) and peach (p. 55) for fuller details.

Powdery Mildew (*Podosphaera oxyacanthae* (Dr. C.) De Bary).

This fungus which occurs on quite a large number of plants is chiefly destructive on the nursery stock of apples, plums, and cherries. It may, however, be found quite plentifully on the foliage of adult cherry trees, where it appears during the latter part of the season. In the nursery stock it grows as a white cottony external coating on the leaves and twigs, dwarfing and stunting these and often entirely preventing the growth of seedling plants. On the leaves of cherry trees the fungus growth is more diffuse, and is usually more developed on their under sides. Later on as this growth turns brown or disappears there are developed from it numerous minute round bodies, which the light coloured at first, but afterwards become reddish-brown and finally black. In these the spores are produced which carry the fungus over winter.

As mentioned already, the fungus does not appear before the middle of the season, after the crop is picked, and for this reason it is considered by many to be quite harmless. It must be remembered, however, that the leaves are the factories of the plant, and that they must produce food for next year's buds and flowers besides a quantity of material which is stored up in the plant over winter. The Powdery Mildew, by reducing the vitality of the leaves, seriously interferes with their functions, and the effects of the attack are seen in the next year's crop.

This phase of fungus injury is hardly ever given sufficient consideration, and many growers, who prune for next year, and fertilize for next year, overlook the equally important fact that this year's leaf diseases may take heavy toll from next season's crops.

Control measures should include destruction of the infected leaves and a cleansing spray in the spring of lime-sulphur or Bordeaux. If this is not found sufficient, a couple of sprayings with self-boiled lime-sulphur or Bordeaux as the disease is commencing will probably be effective since the fungus is mainly external and for that reason easily killed. Potassium sulphide is also recommended, and for those who have only a few trees, sulphur dust may be applied.

Shot-hole (*Cylindrosporium Padi* Karst.).

The well known Shot-hole effect, so frequent on the leaves of cherry as well as of plums and peaches, may be due in particular instances to various agencies, but in this neighbourhood by far the greater part of the disease is due to *Cylindrosporium*. A similar trouble is caused by another fungus, *Cercospora circumscissa* Sacc., but it has only been found here by the writer occasionally.

A number of other leaf fungi also produce shot-holes under certain circumstances, and the same effect may be brought about by the action of drops of spray materials.

On the cherry the fungus produces a leaf spot which is small and reddish at first. Later on it increases in size and the central portion becomes brown, dies, and falls out, thus producing the characteristic shot-hole (fig. 44). Several of these holes may occur in close proximity, and a ragged hole in the leaf results. In some cases, the spot does not reach the shot-hole stage, but remains small and reddish-brown. This seems to be the case when a late infection arises, and one often meets with this condition on sweet

Fig. 44

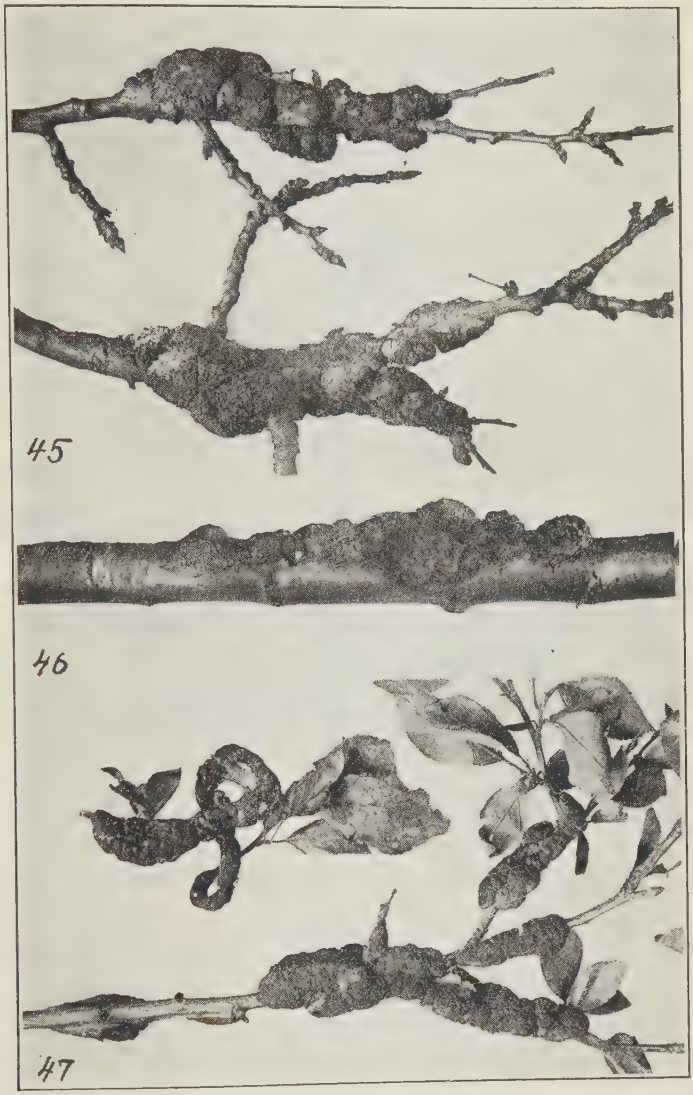
Shot Hole of Cherry leaves. The photograph was taken at the time the small dead areas were about to fall out.

cherry trees in the fall. The spores of the fungus may be seen in the centre of these spots in small greyish masses.

Very little Shot-hole on a leaf is sufficient to disturb its functions and reduce its food-forming power to such an extent that the leaf falls early. Premature defoliation from this cause is very common, and is a serious loss to the tree since the leaves are responsible for the building up of food materials for the next season's buds and blossoms. It is noteworthy that young trees are more susceptible than older ones, and that weaker trees are more severely attacked than those in vigorous healthy condition. Sour cherries are not so much affected by the disease as the sweet varieties.

The source of infection in the spring is not completely known, but there is no doubt that the leaves play an important part in carrying the fungus over winter. Pustules of the fungus have also been found on the young shoots, and it is likely that these might be sources of infection as well as spores derived from leaves, which have remained in cracks and crevices of the bark. Treatment should in any case require the destruction of the old leaves by ploughing them under, and a cleansing spray in

spring before growth starts. Lime-sulphur answers very well for this purpose. If further measures are desired, the disease can be controlled by about three sprayings of Bordeaux mixture, the first applied two weeks after blossoming, the second just after the fruit is picked, and the third a month later. On account of the danger of burning the foliage, the mixture should either contain an excess of lime to render it alkaline or be reduced to half its strength. The latter appears to be effective in controlling the disease, and has the advantage of cheapness.



Figs. 45 and 47. Black Knot on the branches of wild plum.
Fig. 46. Black knot on a cultivated plum. Infection took place in this case at a frost crack.

PLUM.

Black Knot.

See under cherry (p. 42).

Leaf Curl (*Exoascus deformans* (Berk.) Fuckeal).

The Leaf Curl attacking the peach has also been reported on the Japanese plum, where it causes the same distortion and falling of leaves (p. 57). Such cases are apparently not common, but where it does occur, the treatment used for the peach will be effective here also.

Plum Pockets, Bladder Plums (*Exoascus pruni Fckl.*)

This fungus which often occurs on the wild plum, is occasionally found on cultivated species, and especially on American varieties. Soon after blossoming the fruit becomes much enlarged, its tissue is light and spongy, and instead of the stone a hollow space develops within it. This space is sometimes found filled with gum. Nearly all the fruits on a tree may be affected, or only a few, and such trees will continue to bear Bladder Plums year after year. Cool, damp weather in the early spring is favourable for the disease, which is closely allied to Peach Leaf Curl. The disease appears to be scarce in the Niagara peninsula on cultivated plums, but where troublesome the same treatment as for Leaf Curl is recommended, viz.: A cleansing spray in spring on the dormant wood supplemented by destruction of the affected fruits of last year's crop (see p. 60).

Rust (*Puccinia Pruni-spinosae* Pers.).

This rust has been recorded as occurring on plum, peach, apricot, and almond, as well as on several varieties of wild plums, and it is said to be severe under moist, warm climatic conditions. So far as can be learned, it does not appear to be either common or serious in Ontario orchards. On the plum the rust appears on the leaves, but in the case of the peach and apricot it also occurs on the fruit. On plum leaves it forms minute brownish pustules, which may be so numerous as to give the leaf a decided brown colour. The leaf is so weakened that it falls early and if the disease is severe, considerable defoliation may result. The fungus is said to have an alternate stage on the common Hepatica in the spring.

Shot-hole, Leaf Spot (*Cylindrosporium padi* Karst.).

The Shot-hole fungus which causes defoliation of the cherry also occurs on the plum. On a good many varieties it causes merely a brown or reddish-brown leaf-spot, but occasionally the central portions of these spots die and fall out, producing the true shot-hole effect. This is particularly the case with Japanese plums, on which the disease is likely to be severe if the trees are unhealthy in any way. The treatment is the same as given under the cherry (p. 46).

Sun Scald.

Plums seem to be especially susceptible to this form of winter injury (see p. 17). Whole plum orchards are to be met with, in which a strip has been killed on the southwest side of every tree (fig. 48). The extent of the injury varies from a small strip to one involving almost half the trunk. A coat of paint applied to the exposed portion, after removing the bark, will materially assist recovery and lengthen the life of the tree by preventing insects and fungi from having access to the heart of the tree. The tree shown in fig. 48 suffered a severe sun scald several years ago, and was painted with ordinary paint. The heart wood is still quite sound, and the tree is bearing well in spite of the large wound in its trunk.

Three means of preventing scald have been used in various places:—

1. A coat of whitewash given in fall which by reflecting the sun's rays prevents overheating in winter at the time when the scald takes place.

2. A strip of board lightly fastened to the south or southwest side of the trunk serves the same purpose.

3. A strip of building paper tied loosely around the trunk in the fall likewise protects it from the heat of the sun in winter and early spring.

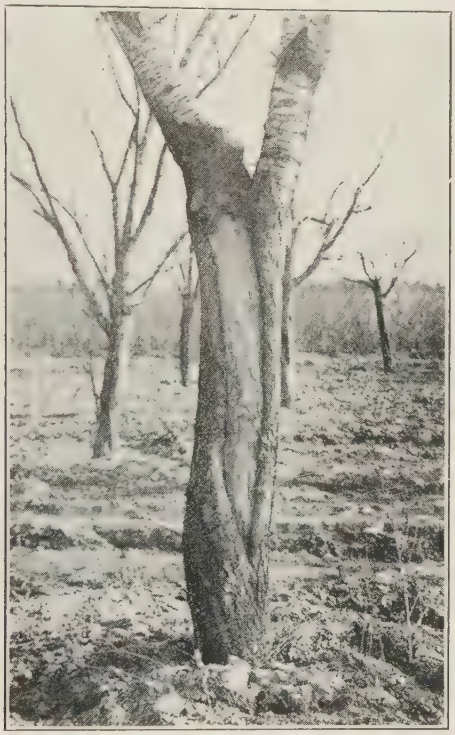


Fig. 48
Sun scald on a plum tree.

Brown Rot of Stone Fruits; also called Mold, Ripe Rot, Grey Rot and Soft Rot

[*Sclerotinia fructigena* (Pers.) Schroet.]

This is the worst trouble to which the fruits of peaches, plums, and cherries are subject. It also occurs on apples, pears, and quinces, but is less severe as a rule on these. (See figs. 42, 43, 49.)

Since the action of the fungus is very similar on all the fruits mentioned, the description given here will apply to them all. It begins as a brown spot in the flesh of the fruit under the skin, and although the fungus very often gains an entrance through some lesion in the epidermis, as for example the stings of the curculio, it is also able to pierce the unbroken skin of the fruit through the stomata or breathing pores. The brown spot rapidly enlarges and strikes deeper into the fruit until the whole of it is involved. The flesh of the affected part is brown, soft, and watery at first, but in the early stages there is no shrinking of the tissue. Later on, however, the fruit dries out rapidly and shrinks up into a wrinkled and shrivelled mass, which is

very aptly termed a "mummy." If conditions have been favourable during the progress of the rot the fungus will grow out from the epidermis here and there in tufts, which are made up of sheaf-like masses of threads. On the ends of these threads, the spores are borne in countless numbers. If one rubs one of the tufts lightly with a finger, the spores come off on it as a greyish powder. Most of the rotten fruits will fall from the tree early, but in some cases, especially if the tree is unhealthy, they shrivel up on the tree and remain there as mummies till the following year. From the rotten fruits the spores are spread to healthy ones by wind, rain, insects, and other agencies, and those which remain on the tree may become a dangerous source of infection during the succeeding year.

The various stone fruits are most susceptible to attack after the fruit is half-grown, but earlier stages and even blossoms may be affected as well. The point of contact of two or more fruits seems to be a favourite place for the development of this rot. The epidermis is weaker at this point, spores find ready lodgment there, and rain and dew water are held for a long time by capillary attraction. For the same reason rot is often started where a leaf is stuck to the fruit or where the latter rests against a

Fig. 49
Brown Rot in p ums.

branch. Through the point of contact also the disease rapidly passes from one fruit to another, and one often meets with bunches of cherries and plums where the fungus has passed from one to another until the whole of them were involved (see fig. 49).

Occasionally on the plum and cherry, but very frequently on the peach, the Rot fungus, after destroying the fruit, grows down its stem into the twig and kills it. Often, too, the small branch on which this shoot grows is girdled by the fungus and dies (see fig. 55). The loss of a few twigs and branches in this way is usually not important in such a quick-growing tree as the peach, but a more serious effect of this sort of twig injury results when a canker is formed on a large limb at the base of a twig killed by the rot. This phase of Brown Rot activity is taken up more fully under Canker (p. 53). In the accompanying photograph (fig. 54) two fruit pedicels are to be seen in the centre of a canker, which has evidently been started by Brown Rot in the fruits which they bore.

After falling to the ground, the affected plums, peaches, and cherries rot completely and during the fall the fungus forms within them hard, black masses (sclerotia). It is the common practice to plough the ground in the fall, and hence the sclerotia are covered over winter. Early in spring many of these near the surface

send up small trumpet-shaped growths (apothecia) which produce an abundance of spores of a type quite different from those of the fruit rot. (figs. 50, 51). These spores are capable of starting infection once more. It has been claimed that it is only from mummies that have lain two winters in the ground that these apothecia are produced, but the observations of the writer tend to show that they may grow quite freely from those mummies which have passed but one winter (fig. 51). It has also been thought that this apothecial stage occurs too rarely to be important in starting infection again in spring. It was, however, plentiful enough in the peach and plum orchards of the Niagara region last spring (1913), and was also found here in considerable quantities in 1912.

Since the ordinary spores of the fungus may be produced to quite an extent from mummies in the spring, it is very probable that both means are instrumental in carrying the infection over into the succeeding year.

In any case it is evident that one important means that must be adopted in dealing with this disease is the destruction of all the rotten and mummied fruit both on

Fig. 50 Fig. 51

50. Spring stage of the Brown Rot fungus on a peach buried just at the surface of the ground.
51. Spring or apothecial stage of Brown Rot on plums. The seeds are germinating while the trumpet-shaped apothecia are growing from the flesh of the buried fruit.

the tree and beneath it. If these are ploughed under they should be covered by at least 3 inches of soil in order to make sure of no further growth. The numerous apothecia found by the writer have all been produced from mummies within 2 inches of the surface, and it is probably rarely that they are able to grow from a greater depth. In addition to this the spring spray of lime-sulphur will be very effective in cleansing the tree from all spores lodged on the bark, twigs, and buds. A further protection to the crop may be given by three sprayings with self-boiled lime-sulphur, as given under Peach Scab. Even if the destruction of the old fruit and the spring spraying are done thoroughly complete protection is not assured, for the spores are borne long distances by the wind and the Brown Rot fungus is so universal in its occurrence that the orchard is exposed to infection continually throughout the summer. Hence the possible need for the protective spray of self-boiled lime-sulphur.

PEACH.

Canker, Gummosis.

Peach trees in common with other stone fruits possess the faculty of throwing out gum when wounded in any way. Cracks in the bark, cuts or bruises on the stem or holes made by borers, all have associated with them more or less gum flow, which is a normal part of the tree's functions. Such wounds heal over in a short time, especially in such quick-growing trees as the peach, and injuries of this sort are to be carefully distinguished from the unsightly open sores, which have infested our peach orchards in recent years, and to which the name of Gummosis or Gum Cankers has been given. The accompanying photograph (fig. 52) will describe sufficiently these abnormal lesions, which, when the exuded gum becomes old and black, resemble huge specimens of Black Knot in appearance. The amount of damage caused by these cankers is far greater than is generally suspected, and in some parts of the peninsula they are so common that upwards of fifty may be found on a single tree.

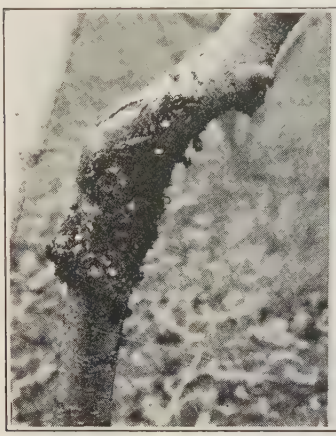


Fig. 52

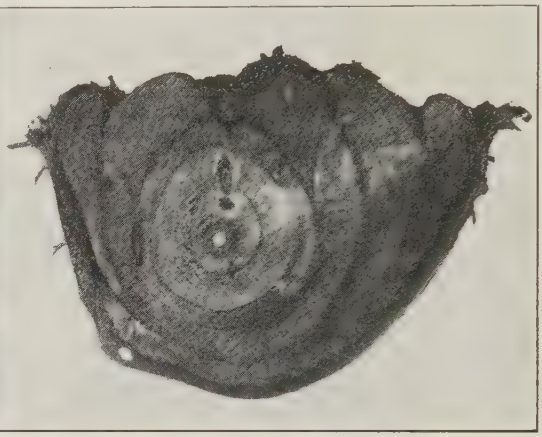


Fig. 53

52. A typical peach canker.
53. Section of a peach canker showing the yearly increase of the cankered area.

Unlike ordinary wounds, the cankers increase in size from year to year, both along the limb and around it, so that in a few years the normal living tissue at this point is so reduced that the limb is girdled and dies. The photograph of a cross-section from one of these cankers (fig. 53) shows the growth of each year starting farther back, owing to the killing of the wood at the edge of the canker. Where a limb killed in this way is small, the loss is unimportant, but many large branches are lost each year in an orchard where canker is prevalent. The loss is still more severe when cankers form on the trunk or work around the crotches where the main branches join with the stem. Then the whole trunk may be girdled or one or more of the main limbs destroyed, involving the loss of a considerable part of the tree. Even if a limb is not wholly killed, it often happens that the exposed heart wood in the canker is attacked by rot fungi and so weakened that the limb breaks off readily in the stress of a storm or with the weight of a fruit crop.

The cause of cankers has been assigned to several agencies. The popular idea that they are due to peach borers arises from the prevalence of larvæ in the succulent tissue around the edge of the canker, but these are never present when the canker is

formed, and many cankers are without them altogether. These larvæ do considerable harm in destroying the soft living tissue surrounding the canker, and thus assisting in keeping it open, but they ceratinly do not cause it in the first place.

An extended examination of large numbers of cankers has established the fact that there are several points of origin for these sores.

(1) A very small percentage arise from holes made by borer larvæ.

(2) They may come as an after-effect from small cracks in the trunk or limbs. The percentage thus formed is also very small.

(3) A small number start from gum blisters under the bark.

(4) A few arise at the bases of twigs killed by Brown Rot. The Brown Rot fungus works back from the rotten fruit into the twig and then starts a canker in the larger limb, as illustrated in figs. 54, 55.

(5) Wounds made by scraping the limbs, etc., are accountable for a small number.

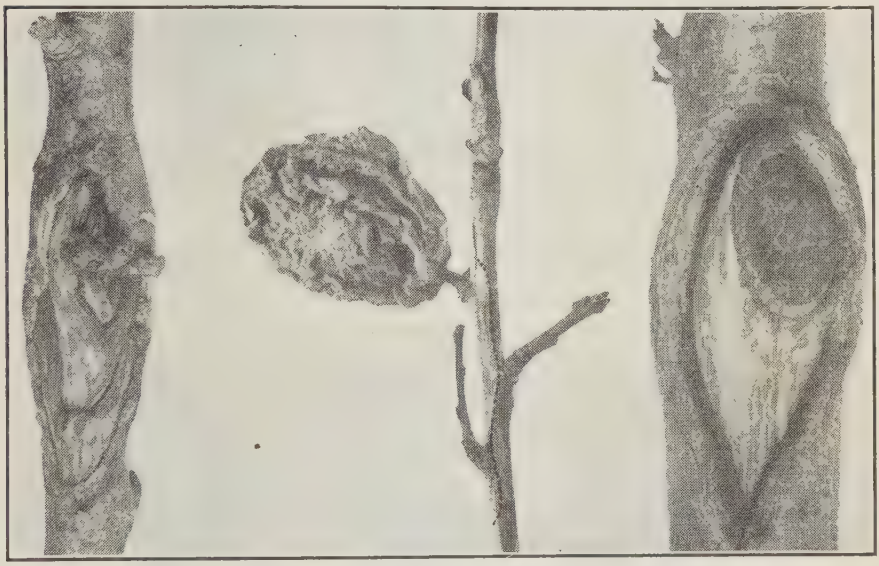


Fig. 54 Fig. 55 Fig. 56

54. A peach canker which started from a fruit spur.
55. A peach "mummy" (i.e. a rotten fruit which has dried up on the tree.) The branch on which it is borne has been killed by the Brown Rot fungus in the area indicated by the dotted line.
56. A peach canker starting from a pruning wound.

(6) Quite a few cankers start at pruning wounds, as shown in fig. 56.

(7) By far the greatest proportion of cankers are formed on the limbs at the bases of dead twigs. There is presumably a fungus concerned here which, after establishing itself in the dead twig, runs back into the larger limb and there starts a canker. Three incipient cankers started in this way are shown in fig. 57, and in fig. 58 the same three appear, with the dead bark and gum removed to show the extent of the injury.

An hour's observation in a cankered orchard will convince any one that the last-mentioned method of origin obtains in at least 75 per cent of the cankers present. The proportions arising in the other ways mentioned are usually small and will vary a good deal according to conditions.

As regards other factors which might have an effect in canker formation, it may be stated that there is good reason to believe that the winter plays a prominent part

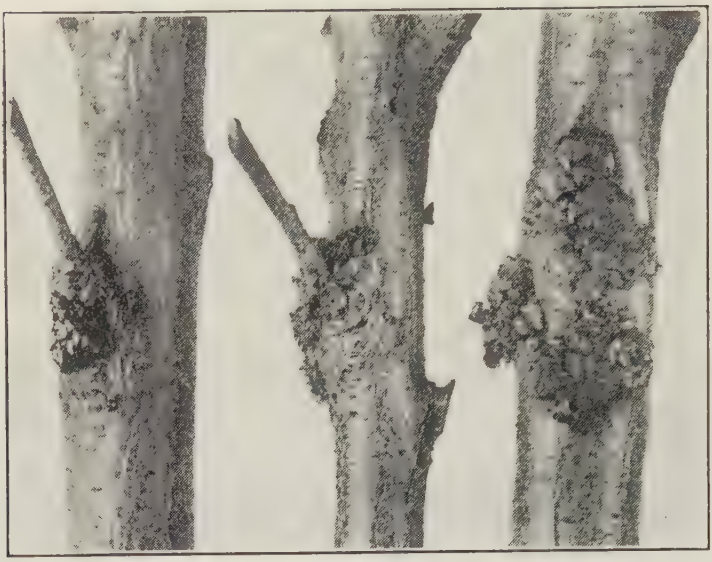


Fig. 57

Three peach branches showing cankers arising at the bases of dead twigs.

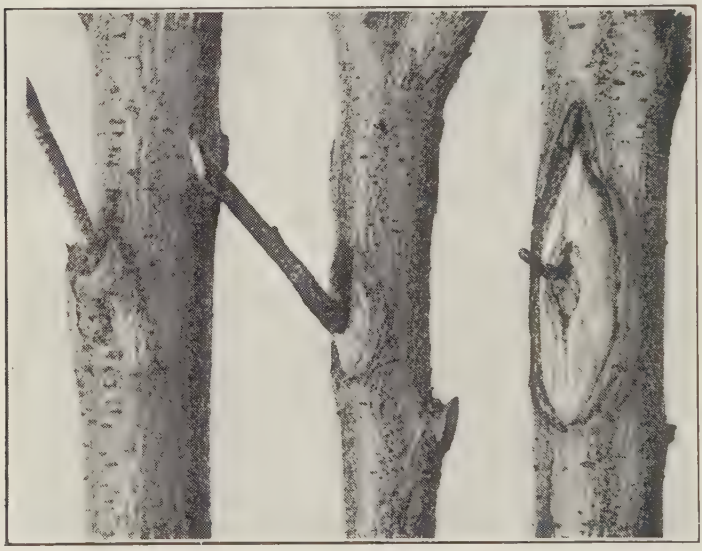


Fig. 58

The same as above with the gum and dead bark removed, to show the extent of the cankered areas.

in the process, by freezing the tender unripened callus tissue around the canker and thus extending it. This and other phases of the disease are being investigated, and the results will shortly appear in the form of a special bulletin on the subject.

The treatment of cankers naturally falls under two heads: prevention and cure. As to prevention, emphasis must be placed on the removal of dead twigs from the main limbs, since it is found that these twigs are the starting points of the disease in such a large number of cases. For the same reason it will be advisable to remove the Brown Rot mummies from the tree so that canker from this cause may be avoided. The painting of all the larger pruning wounds would also prevent the formation of dangerous cankers in many cases.

Methods of cure for cankers already formed can be confidently given, although on account of cost such methods will be mainly applicable to those cankers whose situation makes them dangerous to a large part of the tree. It is obvious that it is easier to cut off a small canker and grow a new limb from below than to treat it with the hope of saving the limb, for the results would not justify the time and cost of treatment. But the case is different with those cankers which threaten the stem or main limbs. These are well worth trying to heal up, and one can assist nature's efforts to bring this about to a considerable extent. It should be remembered that cankers are for the tree very much like running sores on the animal body, and that the same general methods of treatment should be adopted, involving cleansing, a disinfecting wash, and a protection. It is better to clean out a canker immediately after a rain when the bark and gum are soft and easily removed. It is certain that this gum has an injurious effect on the canker, for it is found that under it the tissue is in a less healthy condition than where the wood is exposed to sun and air. Besides this the gum masses give protection to the larvæ which were mentioned above, as well as to several rot fungi which attack the heart wood. These fungi may not grow directly in the gum, but the latter has the property of holding moisture for a long time, and this makes a condition in the canker favourable to fungus growth. All the gum, therefore, should be removed, as well as the dead bark from the centre and edges of the canker. The main idea in all this treatment is to expose the canker as much as possible to the sun and air and to keep it dry. Even if nothing further than this cleaning out were done, the canker would now have a reasonable chance for recovery. It is better, however, to follow this cleansing with a wash of some ordinary disinfectant such as commercial formalin diluted one in ten, or corrosive sublimate of a strength of one in a thousand (see p. 70). This wash will effectually kill all fungi and bacteria present on the surface, and prevent them from rotting the heart wood, or irritating the young growing tissue. Then in order to protect the wound from future invasions of such enemies, a protective coat of some kind should be applied. Whitewash is very good, cheap, and easy to apply. Paint, however, is better, because it lasts much longer. A coat of ordinary lead paint will last for several years, will not allow moisture to be absorbed, and prevents the inroads of insect larvæ or rot fungi (figs. 59, 60, 61).

From estimates based on actual work in the orchard, it is found that the cost of treatment would amount to at the most, 4 or 5 cents per canker, and where these are dangerous to the tree, it is well worth while to look after them. The best time to do such work is early in summer, so that the young growth around the canker will have a chance to harden and mature before the winter comes on.

Crown Gall, Root Gall (*Pseudomonas tumefaciens* Erw. Smith & Townsend).

The round, knob-like growths found on the roots of numerous trees and shrubs have already been discussed under the apple (p. 25). They are frequently found on the peach, especially on nursery stock, which in the young condition seems to be very

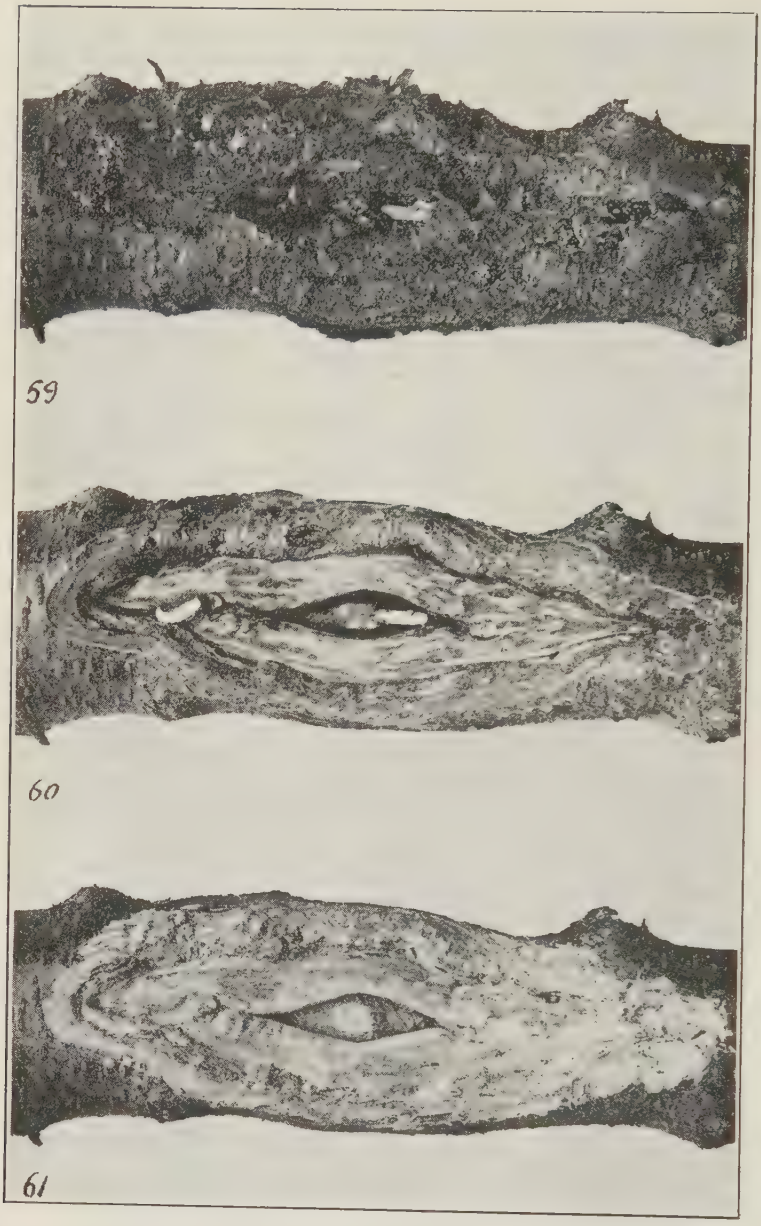


Fig. 59. Canker on peach tree before being cleaned out.
Fig. 60. The same cleaned out. Note the twig in the centre from which it started, and also the larva which has been feeding on the soft tissue at the edge.
Fig. 61. The same canker, which has been washed with corrosive sublimate and then covered with lead paint.

susceptible to infection (fig. 62). There can be no doubt that in many cases the galls stunt and weaken the growth of these trees, especially if the gall is large and forms on the crown. It is a matter of observation, however, that as the tree gets older the galls tend to disappear so that fewer galls are found on the 3-year-old than on 2-year-old stock. Since the setting-out of affected nursery trees is practically the only means of introducing the disease, the advisability of planting such stock is the most important question that arises in reference to Crown Gall. A due consideration of this question in all its bearings would make the answer decidedly "no."

The only advantage that is gained by using such trees is in their first coat. On the other hand, there are several important reasons against planting such stock. In the first place, the galls are undoubtedly damaging to some trees, especially when they occur on the crown. Such trees, even if they finally survive, are retarded in growth for several years, and it is unwise to take such chances with a young orchard. Moreover, as mentioned under the apple, the rotting away of a gall, especially one on the crown, leaves just the sort of wound that is favourable for the entrance of rot fungi into this part of the tree. Last and most important of all is the danger, almost the

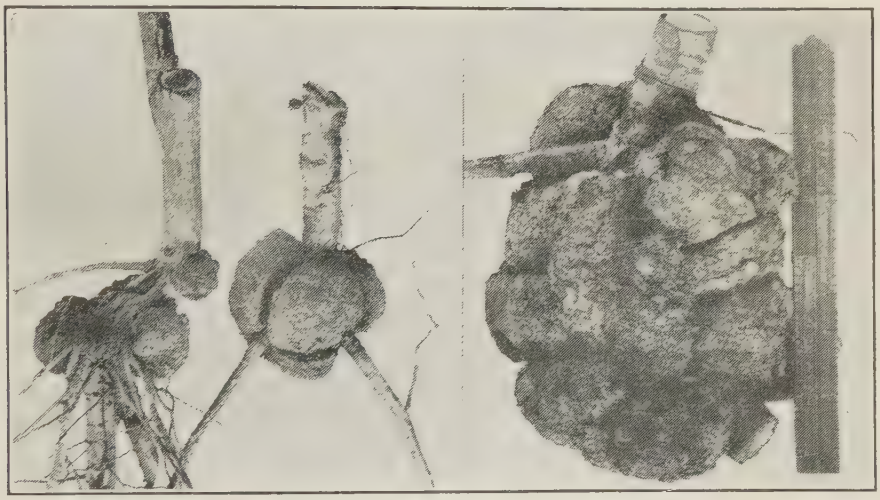


Fig. 62
Crown gall on a nursery peach.

Fig. 63
A large gall from an old peach tree.

certainty, of introducing into the land an organism capable of attacking a great number of hosts, among which there are some, like the raspberry, that suffer severely from its attacks. This danger is the more to be avoided because the disease once established lives on in the soil, and no remedy has yet been found to rid the land of its presence. It is the practice of the best peach-growers to discard and burn at the time of planting all those trees which are affected by Crown Gall in any degree.

June Drop.

The falling of large numbers of peaches in June or earlier is a trouble that sometimes occurs. According to Ohio pathologists, it is due to over-bearing, or drought during the previous season.

Leaf Curl (*Exoascus deformans* (Berk.) Fuckel).

Aside from Yellows and Little Peach, there is no disease so destructive to the peach as Leaf Curl. Its occurrence only on the leaves and twigs and practically never on the fruit lead many people who do not understand the general functions of a tree

to far underestimate its importance. It should always be borne in mind that the leaves are the food factories of a plant, and that nearly all the materials needed for the year's growth and for the building up of the fruit must be elaborated in them. Moreover, each season a new set of buds must be started for next year, and a certain amount of food stored up in the tissues to supply the plant till next year's leaves are far enough advanced to take up their duty. It is evident then, that such a disease as Leaf Curl, which so seriously injures the foliage, has great and far-reaching effects on the life of the plant; effects which in some cases fall not far short of complete starvation.

The various results which follow a severe attack of the disease may be noted as follows:—

1. Total or partial failure of the year's crop.
2. Stunting of the year's growth, both in lengthening of the branches and thickening of the stem and limbs.
3. In case a new set of leaves is put out to replace those lost by the Curl, there is a severe drain on the plant's resources at a time when it is least able to meet it.
4. Such a second set of leaves involves late growth, and the wood entering the winter unripened is liable to winter injury.
5. The buds for next year's leaves and fruit are likely to be fewer and weaker, and the food stored for spring growth less in amount, so that the prospects are much less favourable for a good crop the following season.
6. Young trees recently set, and not yet adjusted to their new conditions, often die outright after a severe attack.

The Leaf Curl fungus attacks the tissue of the leaf in patches, which vary a good deal in size. They may be as small as a quarter of an inch in diameter, or so large that the whole leaf is involved. Often all the leaves on a shoot and even the shoot itself is attacked (figs. 64, 65. 66).

The leaf tissue in the affected patches grows thick and fleshy, and so much distortion results from the unequal growth that the leaf curls up in characteristic fashion. The colour of the patches varies from pale yellowish-green to a distinct reddish tinge. Later on the patches are covered by a greyish furry or velvety coat, and on brushing this with the finger it will be found to bear innumerable dust-like spores. After spores are produced the leaf withers, dries out, and falls off. Where only a small amount of the leaf is involved the affected spot drops out, leaving a "shot-hole" comparable to those produced by the Shot-hole fungus (see fig. 69). When twigs are attacked they remain short and become greatly thickened. Such shoots frequently die, and a bud below takes their place; in other cases, they seem to recover and grow normally. Fig. 66 is a photograph of a number of affected twigs taken in the fall succeeding a severe attack. Those which have been killed are being replaced by a bud starting from below, and others show various degrees of recovery.

The Leaf Curl is found almost everywhere that peaches are grown, and, while it does not occur every year as a serious pest, it is, on the average, bad about half the years. This variation is due to weather conditions at the time of infection in early spring. Dry, warm weather at this time is unfavourable to its development, but the infection is likely to be severe if at that time cold, wet weather prevails. Apparently the spores from the leaves of the preceding year are lodged on and around the bud scales. where they start to germinate with the first coming of growth in spring. If the weather is cold and wet, the tissues of the young leaves are more or less water-soaked and as the fungus is little hindered by the cold, the infection of the slowly-growing young leaves is very large. On the other hand, dry and warm conditions promote the rapid expansion of the leaves, so that the time of infection is greatly reduced. The leaves under such conditions are also less saturated with water, and this seems to be an added protection against infection. It was formerly thought that the infection began from twigs in which the fungus had passed the winter, but it is now believed

Fig. 64 Fig. 65 Fig. 66

64. Peach foliage and twig attacked by Leaf Curl.
65. Peach leaves attacked by the Curl disease in spots.
66. Peach twigs after an attack of Curl. The two on the right have been killed, but those on the left are recovering.

that this source of infection is insignificant, and that the greater part of the disease arises from spores lodged on and about the bud scales. Definite knowledge on this point enables us to attack the disease with surety and certainty, and where careful spraying is carried out, its inroads are no longer feared. The usual mode of treatment is to spray with lime-sulphur just before the buds swell. Bordeaux mixture is equally good, but as in the peach districts of Ontario San José Scale is always more or less present, the lime-sulphur is preferable since it will control the scale while Bordeaux will not. It is of extreme importance that the spraying be done early, just before the buds swell, and that every bud be covered with the spray mixture. If care is taken to observe these two points the disease can be controlled almost absolutely.

Fig. 67

Tip of branch of "Toronto" peach. Foliage dwarfed, bleached, and covered with the frost-like growth of the fungus.

Failure to control it is due to either too late spraying or to incompletely covering the buds with the spray. It is advisable to put the spray on during the two weeks preceding bud swelling, as, if applied earlier the results are not quite so reliable.

Twig Blight.

A large number of dead and dying branches of peach trees are found to be studded with the minute black spore pustules of this fungus, breaking through the bark like small pimples. Under certain conditions, tiny reddish or pink threads of spores may be seen extruding from these pimples. As the spore threads are readily washed away by rain, they may not be seen very often on the tree, but if a twig is stuck in a bottle with an inch of water in the bottom they will appear on it inside the bottle in a few days. The fungus is said to be able to attack and kill living twigs, but according to

the writer's observations, it usually comes in when the twig or branch has been greatly weakened in some way, as for instance on those branches nearly girdled by Brown Rot or by Canker, on winter-killed twigs, or on trees suffering from Yellows, San Jose Scale, or Collar Rot. Even if not a very energetic parasite, it is sufficiently important to warrant attention. All dead and dying wood liable to attack should be taken out and care should be exercised at pruning time to remove the already infected branches, which, if left, become a centre from which further infections may spread.

Powdery Mildew (*Sphaerotheca pannosa* (Wallr. Lev.).

This mildew, which is common on roses everywhere, also attacks the peach, and in damp, warm weather may become a serious nuisance. The leaves, young shoots, and occasionally the fruits are affected. The leaves and twigs are dwarfed and distorted, have a bleached appearance, and are covered with the white frost-like growth of the fungus (fig. 67). The disease is apt to be bad in moist, warm weather on crowded nursery stock. Older trees are less liable to attack with the exception of certain sus-

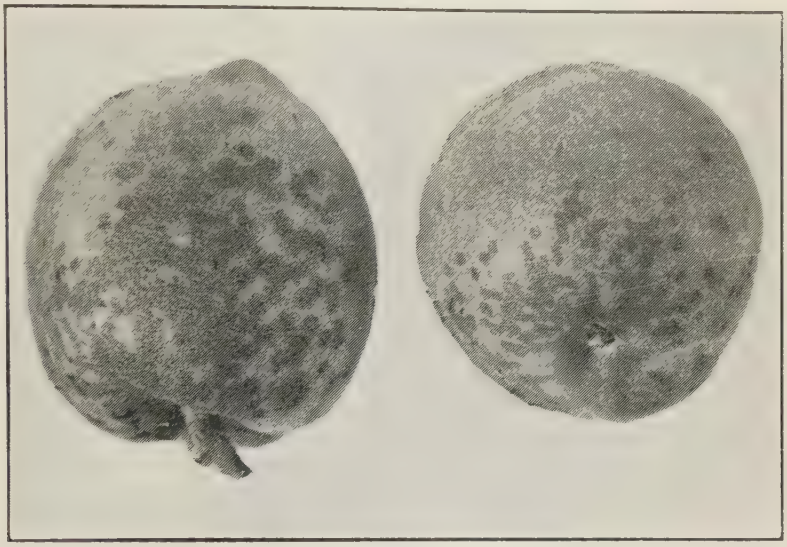


Fig. 68
Peach Scab.

ceptible varieties, among which the Toronto, Brecken, and Great Northern are notable in this neighbourhood.

Dusting with flour of sulphur at intervals of ten days is effective against mildew, and ammoniacal copper carbonate or self-boiled lime-sulphur are also recommended. In general orchard practice, however, it is usually better to replace the susceptible varieties than to treat them for the disease, especially since they are found to be a constant source of infection for neighbouring trees in the orchard.

Rust (*Puccinia Pruni-spinosae* Pers.).

This Rust is rarely met with on the peach in Ontario. In parts of the United States it is said to be severe at times on peach foliage, but though occasionally present in Ontario on the plum it does not seem to be at all common.

Scab (*Cladosporium carpophilum* Thum.).

The fungus causing the scab of peaches is also responsible for a similar affection of apricots and plums. It is very widespread on peaches, and is particularly prevalent

on some few varieties, such as Hill's Chili, Triumph, Champion, Longhurst, and Early Rivers. There are found on the fruit shortly before ripening small round sooty spots which either occur separately or coalesce to form dark patches, often involving one-half the fruit (fig. 68). Although the growth of the fungus is very superficial it prevents the ripening of the tissue beneath, and this part will remain hard, green and bitter when the rest of the peach is ripe. There is also a tendency to crack in the scabbed areas. The disease is very disfiguring and hopelessly injures peaches for market.

The leaves of the plant may also be attacked, and a distinct spot results, from which the centre may fall and leave a "shot-hole" similar to those produced by other fungi. The fungus may also grow on twigs, on which it forms purplish-brown spots, which survive the winter and produce spores in the spring.

The early spring spraying with lime-sulphur is very useful in preventing scab. It not only destroys the spores lodged in various parts of the tree, but prevents any scab spots on twigs from becoming sources of infection. In ordinary practice in the Niagara peninsula, no other treatment besides this general spraying in the spring has been found necessary. In case further treatment is desired, the self-boiled lime-sulphur, which is also useful against Brown Rot, may be applied. The first application should be made about three weeks after the petals fall, since infection of the fruit is found to take place a month or six weeks after the blossoming period; the third about a month before the fruit is ripe; the second midway between these two. For early varieties, this will be sufficient, but a fourth may be necessary in the case of late-ripening varieties.

Shot-hole, Leaf Spot (*Cylindrosporium padi* Karst.).

The Shot-hole fungus of the plum and cherry also affects the peach, but to a much less extent. It is usually worst on young trees, especially if these are lacking in vigour, and occasionally it is more or less severe on older trees which have been weakened from some other cause. Indeed, Shot-hole on the peach may be considered as an excellent indication of unhealthy conditions in the tree. When the disease is present, therefore, it is well to look for evidences of other troubles such as winter injury, lack of nourishment, etc. If these are attended to and the tree restored to a healthy condition, the Shot-hole will usually disappear.

A severe attack of Shot-hole on the leaves is sometimes mistaken by the grower for Yellows and a good many trees have been unnecessarily removed in this way. The sickly yellow condition of the leaves is responsible for this mistake, but a close examination will show that there is a good deal of red in the leaves, which is not present in Yellows. The spot caused by the fungus is usually redder and more diffused than in the case of the plum and cherry. Very often there is no "shot-hole" to be seen, the fungus either remaining in the red spots without killing the tissue, or else areas are killed and fall away from the edge of the leaf, giving it the ragged appearance seen in fig. 69. Very little Shot-hole fungus on a peach leaf is sufficient to damage its food-producing power, cause it to turn yellow, and finally drop off.

Ordinarily no special treatment beyond the spring spraying with lime-sulphur and the ploughing down of old leaves will be needed, but should such be desired, the Bordeaux spray recommended for the plum and cherry will prove effective here also (see p. 46).

Besides this well-known Shot-hole fungus, several other fungi may produce somewhat similar spots and holes in the leaves of peaches. *Cercospora circumscissa* is one of these, and *Bacterium pruni* is said to act in the same way. The same effects may also be due in certain cases to Scab (*Cladosporium carpophilum*) and to Leaf Curl (*Exoascus deformans*), elsewhere discussed (pp. 57, 61).

Splitting of Pits.

This trouble is noticed about the time the fruit is ripening. Damp weather at this period, especially if it has been preceded by dry weather, produces a rapid and unequal expansion of the fruit, with the result that the two halves of the pit are forced apart and a gaping split is formed at the stem end. Fungi sometimes grow in the pit cavity and about the split and are rather disfiguring to the fruit. Elbertas seem to suffer most from this cause.

Winter Injury.

The effects of winter conditions on fruit trees generally have been discussed on p. 16. On the peach, the forms of winter injury that may occur are:—

1. Dieback of twigs, which is very common.
2. Killing of blossom buds by severe cold.

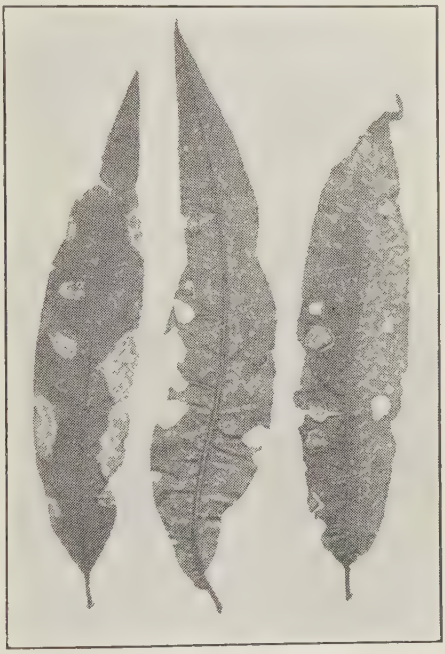


Fig. 69
Shot Hole on peach leaves.

3. Killing outright of trees recently set, of trees with wood unripened, or of trees whose vitality is greatly lowered in some way.

4. Frost browning of the wood throughout the whole of the trunk and limbs. If not too severe, the tree does not seem to suffer seriously from this cause. Examination of a number of peach trees in various parts of the Niagara peninsula shows that a considerable amount of frost injury of this nature occurred during the winter of 1910-11. All the wood formed previous to this time is brown in such trees from the ground or snow-line up to the twigs. Both the later annual rings on the trunk, and the twigs which have grown since then are quite normal and there seems to have been little if any effect on the growth or bearing afterwards. In one orchard, fifty trees, which were being removed because of susceptibility to Mildew, were found to be quite uniformly browned in this way, yet they have been quite vigorous and thrifty ever since.

5. Sun Scald areas, like those which are seen on apples and plums, are sometimes met with on the peach. They are not so common, however, on the peach as on the other trees mentioned, and on account of the tough band-like character of peach bark, they are not so evident because they remain covered by this bark.

6. Collar Rot, the girdling of the tree by the destruction of the living tissue at the base of the stem or crown, and often involving the roots, occasionally is met with in peach orchards. Trees in wet soil, or in soil lacking humus, or those lacking a cover crop or banking, are more liable to this trouble see p. 17).

7. A late frost after the growth has started in the spring may cause splitting of the shoots, and the separation of buds from them. There is usually considerable gum flow from the slits and the bud scars afterwards. Such an injury occurred here and there in the Niagara peninsula during the spring of 1913. The injury is quite distinct from the killing of the buds by very severe cold. In this case, there were only a few degrees of frost, and the injury was mostly mechanical, being due to the expansion of ice in water gorged twigs. That the buds were not injured by the low temperature is shown by the fact that all of them which still retained their vascular or sap-conducting connection recovered and continued their growth. A tree caught by a late frost in this way sheds a large number of its buds, which, after drying out, fall in showers when the tree is shaken.

Yellows and Little Peach.

These two diseases of the peach are included under one heading, both because of their supposed relationship and because the treatment for them is identical. Taken together they are a serious source of loss to the peach grower, and present one of the most baffling problems with which the plant pathologist has to deal. Nothing is certainly known as to the cause of these diseases beyond the fact that they cannot be ascribed to bacterial or fungus parasites. The other hypotheses brought forward to explain them all rest on too scanty a basis of knowledge to serve for more than indications of the lines along which future experimental work may be valuable. In regard to transmission and infection, we are assured from observation and experiment:—

1. That they are transferable by budding and grafting.

2. That they spread in the orchard from one tree to another, though by what means or at what season has not yet been determined.

3. That a tree once attacked never recovers.

4. That a tree planted in the place from which Yellows or Little Peach tree has been removed is not particularly liable to the disease.

5. That the disease is transmissible through the seed.

The last-mentioned point has an important bearing on the spread of the disease through nursery stock, since, if nurserymen bud on seedlings grown from diseased pits, the resulting stock is bound to be diseased. It has been contended that there is no danger from this source, and several authorities are quoted, who claim that few or none of the pits from diseased trees will grow. In order to determine this point for local conditions, the writer has tested the viability of pits collected from diseased trees in the neighbourhood. These were buried over winter in earth, and without permitting them to dry out, they were cracked and planted in spring. Of the 1,200 seeds so planted, 8 per cent grew and produced young trees, which, at present, one year after planting, have shown no sign of disease. Similar experiments conducted by Mr. L. Caesar, using pits taken from other sources and wintered in the same way, gave very much the same result, viz., about 7 per cent. It would seem, there-

fore, that there is some possibility of introducing the disease into an orchard, where these home-grown pits are used for stock at any rate. Such seedlings would pass the budding period without the disease becoming apparent, and, since cutting back tends to obliterate the disease for a time, as mentioned below, the cutting back which follows budding may retard its appearance still more, so that the disease might not show itself in the orchard until several seasons after setting. Most nurserymen, however, endeavour to use pits imported from southern United States, and there is reasonable probability that these are free from disease. Moreover, the manner in which infestation occurs in an orchard seems to indicate that the nursery stock is by no means the most important factor concerned in its spread.

These diseases have gradually spread from the eastern United States to the northwest and south, but there appears to be a climatic limit south of which they will not pass. The region of immunity includes Texas, Alabama, and most of the other Gulf States. Europe also is said to be free from them. All varieties of the peach are subject to them, as well as the Japanese plum, which is almost as susceptible as the peach. Cases are recorded on the European plum, but rather rarely.

The symptoms of these diseases should be carefully learned by all peach growers, so that they may recognize the diseases on their very first appearance in the orchard. The following excellent description of the symptoms is taken from Bulletin 201 of the Ontario Department of Agriculture, by L. Caesar, Provincial Entomologist:—

"SYMPTOMS OF YELLOWS.

"1. The fruit ripens prematurely, being from a few days to several weeks earlier than healthy peaches of the same variety. This premature fruit is usually highly coloured and blotched with red on the outside, and on the inside is more or less streaked with red from the skin to the pit; the flesh around the pit is also much redder than normal. The flavour with a few exceptions, is very poor, being usually insipid and sometimes bitter. Hence, if many such peaches with their fine red colour, but very poor flavour were put on the market, they would soon lessen the demand, even for good peaches, because the consuming public would not be able to distinguish between a diseased and healthy peach. The first year the diseased fruit is usually larger than normal, but the second year it is smaller, and the next, smaller still. Not infrequently diseased peaches are very irregular or knobby on the surface.

"2. On trees in which the disease is well advanced, dormant or concealed buds on the main branches very commonly burst and form little slender shoots with small, narrow, pointed, sickly, yellowish leaves. Sometimes these shoots branch repeatedly. This is one of the easiest means of identifying the disease, but it is by no means always present. In addition to the bursting of these dormant or concealed buds, we commonly find that the buds in the axils of the leaves which should remain dormant until the next spring burst the same year as they are formed.

"3. When the tree is badly attacked, we very often find the leaves turning yellow and becoming curled and clustered in the same way as in the case of Little Peach. In early stages, however, the foliage of the whole tree is usually quite green, and it is only by observing the premature highly coloured fruit on it that we can tell that the tree is diseased. Sometimes only one branch or even one twig will bear such fruit, while that on all the other branches and twigs will be quite normal. Next year more fruit will show the symptoms and the foliage will begin to grow yellow on at least part of the tree. The disease will sometimes kill a tree in two or three years, but usually it will linger on for four or five years. After the first season, the crop is almost always poor and worthless, so that the sooner one gets rid of the tree, the better even from a financial standpoint.

"SYMPTOMS OF LITTLE PEACH."

"Unlike the Yellows, the fruit ripens later than normal, and is usually somewhat smaller, as the name suggests. These symptoms, however, should not be relied on too much, because we have very frequently in almost every diseased orchard found affected trees, on which the fruit ripened about the usual time and was almost as large as the healthy fruit. The second year, the fruit tends to be much smaller, and probably is more uniformly late in ripening.

"Again, in contrast with Yellows, there is none of the high colouring and blotching of the fruit on the outside nor of the red streaking inside. As a rule both the outside and inside have the normal colour. The flavour, however, is usually insipid, just as in the case of Yellows, though apparently there are more exceptions where the flavour is good or fairly good. Still, no one would care to purchase such peaches if he knew they were diseased.

"The most characteristic and reliable symptom of the disease is the peculiar way in which the leaves curl and cluster, and turn an unhealthy, yellowish or often reddish yellow colour. Most of these curled leaves look to be somewhat shorter and flatter than usual, and by the bending of the midrib they curl down at the tip in a claw-like manner. This curling downward and inwards towards the twig helps to give them their characteristic clustered appearance. On some varieties these characteristics are much more conspicuous than on others, and in studying the disease, one should first compare the foliage of various kinds of healthy trees and see how they differ. He will observe that the leaves on the Crawford and closely allied kinds, like Fitzgerald, are quite different in form from those of Smock, Longhurst, Lemon, Free, and several similar kinds, and again that Elberta is different from either of the above classes. St. John is a variety that frequently is inclined to have a yellow tint to the foilage that at first is somewhat misleading.

"After studying the healthy foliage of these trees, examine carefully the foliage of clearly and badly diseased trees of each kind, looking for the symptoms mentioned above. This will give one a picture in the mind to go by, and, having once got it there, there is not a great deal of difficulty in passing on to the identification of the disease in its earlier stages. Attention should perhaps be called to the tendency of diseased Elberta leaves to droop as if the water supply had been cut off, but close examination will usually show, even here, the characteristic curling and clustering and sickly colour on at least some of the central twigs and shoots. Fortunately the disease can easily be identified in young trees from two to five or six years of age, if they are grown in well-cultivated soil. In such cases, it nearly always shows up in the centre or inner part of the tree, where the leaves turn yellowish or reddish yellow, and curl and cluster, while those on the outer and upper parts are still quite green and normal in appearance. One can frequently recognize the disease in such trees 50 yards or more away. Sometimes one sees young trees with all the outer or terminal foliage reddish and sickly, but the central or inner foliage green, vigorous and normal. Such trees are not attacked by Little Peach or Yellows, but usually are somewhat lacking in vigour and often show little brown spots on the leaves, due to what is called the 'Shot-hole fungus' a disease which helps to produce the unhealthy appearance. Trees in sod and those attacked by San José Scale usually have a sickly appearance, and for a little while at first it is difficult to identify the disease on such trees.

"Sometimes late in the season, we find that, as in the case of Yellows, numerous buds have burst in the axils of the leaves and dormant buds on the main branches have pushed forth and produced small shoots. Unlike the Yellows, these shoots never develop into slender bushy twigs with narrow pointed yellowish leaves."

A great deal of experimental work has been done in trying to find a cure for Yellows and Little Peach on the hypothesis that they are due to lack of some substance in the soil. The results, however, have been entirely unsuccessful, and none of the other means employed have given any promise of either curing trees already diseased

or of preventing healthy trees from contracting these diseases. It is true that if a Yellows tree is severely cut back or "dehorned," it will for one or possibly two years produce new shoots and foliage, which are to all appearance perfectly healthy. Of all such cases known to the writer, whether they were so treated by way of experiment or were dehorned as a preliminary to removal and then neglected, none ever recovered finally. In one or two or three years afterwards the disease appeared again. The fact that such temporary apparent recovery does take place is, however, very interesting, and may be useful in further studies of the problem. It is evident that this cutting back of a diseased tree is merely a vigorous stimulus to the natural effort made by the tree to recover itself, as shown by the production of shoots from the trunk or larger branches in the manner characteristic of the disease. The premature development of winter buds on such shoots so as to produce a bushy growth shows quite clearly that nature is making special efforts to replace the diseased top by these shoots and the cutting off of the top gives a chance for all the energies of the plant to expend themselves in the production of such new growth.

The only means that has so far met with success in combatting these diseases is the practice of destroying the trees as soon as they show the first sign of disease. Whenever these trees are allowed to remain, infection seems to follow. In the absence of knowledge on the subject, it cannot be stated that no infection occurs before the disease becomes visible in foliage or fruit, but experience has shown clearly that if the trees are removed at this early stage, such infection becomes reduced to a minimum; and the ravages of the disease in the past must be ascribed to the practice of allowing the affected trees to remain in the orchard long after they were attacked. Under the present efficient system of inspection adopted by the province of Ontario, aided by the hearty co-operation of the fruit growers themselves, these diseases seem to be diminishing in a remarkable manner. Official figures for the last three years show that in 1911 there were taken out from the orchards of the Niagara peninsula about 60,000 trees affected by these two diseases. In 1912, the number was only 25,000, while during the year 1913, the number has dwindled to less than 6,000. It is of course possible that the diminution in the number of cases may be partly due to unfavourable conditions of infection during these years, but there is strong probability that the methods of removal now practised will continue to give as good results in future years as heretofore.

Two inspections of the orchards are aimed at, one early in August or even during July, when the first signs of disease are visible, and another later on in the summer. The trees marked by the inspectors are required under penalty to be removed within ten days. In making such removals, care should be exercised in order to prevent contact of diseased trees with healthy ones, and thus avoid a very possible means of spreading the disease. The common practice combines observance of this important point with ease in operation. The tree is first "dehorned," i.e., the large branches are lopped off close to the trunk. These branches are then carried off and burned, and the trunk and roots removed by a team and chain. It is generally admitted that when the top is thus disposed of, no harm follows if the stump is left till fall when more time is available for such work.

The fight against these diseases can be made much more effective by the promptness with which affected trees are removed. It should be the aim of each peach grower to learn to recognize the symptoms of both Little Peach and Yellows at all stages, and thus be able to do his own inspection without waiting for the visit of the local inspector, so that he can stamp out the disease when it first shows itself in a tree. Those growers who are prompt and merciless in dealing with affected trees are noticed to have a less amount of disease from year to year than those who are lax and neglectful in this respect.

SPRAYS, WASHES, AND DISINFECTANTS.

1. Home-made Lime-Sulphur Concentrate.

This is very easily made. It can be prepared in early spring before field work begins and stored until required for use. A large iron kettle may be used for making small lots or, if large quantities are required, the boiling tank figured below is recommended, as it is cheap and simple in construction and easy to operate. For the needs of large fruit farms an outfit which boils by steam is preferable.

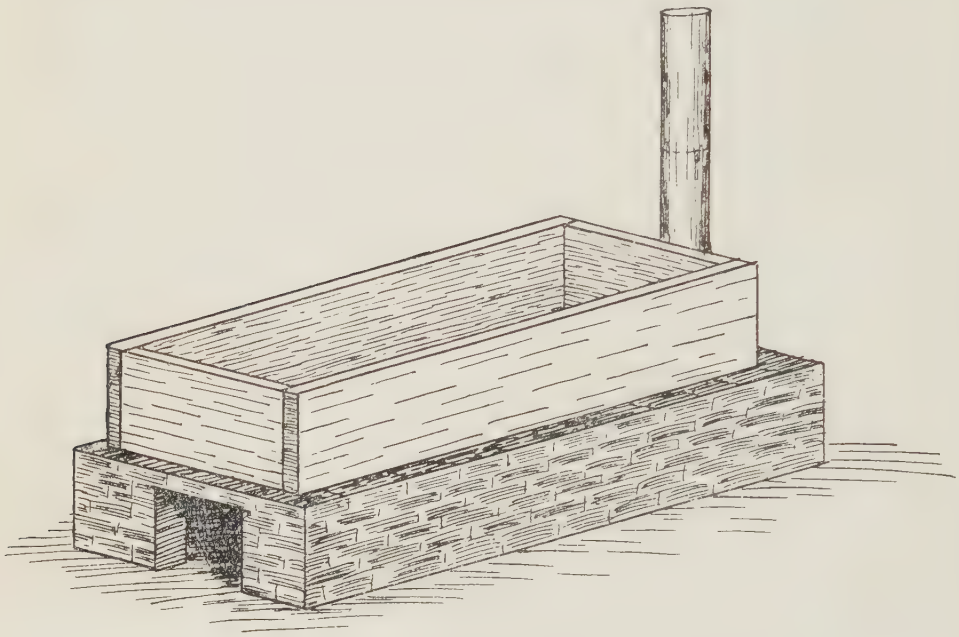


Fig. 70
BOILING TANK.

Type of boiling tank for making homemade Lime Sulphur, in use generally throughout the Niagara peninsula. Dimensions 3′ x 6′ x 1′, the sides of plank 12″ x 2″ and the bottom of sheet iron, well nailed on. The fireplace is made of bricks, stone, cement or earth, with some old pieces of stove-pipe to carry off smoke and create a draft. Care has to be exercised in making this tank to place the fireplace walls a few inches in on the iron bottom to avoid burning the wood. This tank holds about 2 bbls. and costs from $3 to $4.

In order to make the concentrate in 40-gallon lots, the following are needed:—

Good sulphur	100 pounds.
Fresh stone lime	50 "
Water	40 gallons.

The sulphur should be of good grade, and will cost approximately 1¾ cents per pound in 100-pound lots. The lime must be fresh; air-slaked lime is useless for the purpose. It should also have a high percentage of calcium, a low percentage of magnesium, and be as free as possible from earthy materials. Lime costs about 30 cents per bushel of 74 pounds (Niagara peninsula), but the price will vary according to the locality. The limes made from several of the limestone deposits of Ontario are unsuitable for making lime-sulphur, as they do not meet the above requirements.

Put about four pails of water in the tank, add the sulphur and start the fire. Break all lumps and stir the sulphur to a paste. Then add the rest of the water and, when it is almost boiling, add the lime. Boil gently and keep stirred with a hoe until it is all dissolved, which should require about an hour. During this time, keep the

water up to the 40-gallon mark. Then strain into barrels through a screen of thirty meshes to the inch. Do not leave these barrels exposed to the air, but either cover them or pour a thin layer of oil on the concentrate to exclude the air. When cold and the sediment has settled, each lot should be tested with the hydrometer (see p. 72) so that proper dilution may be given when it is about to be used. The cost of making this concentrate, including the materials and labour involved and reckoning on a basis of spraying efficiency, is little more than half that of the commercial concentrate.

2. Commercial Lime-Sulphur, Concentrated.

This may be bought in barrels, etc., and costs about 17 cents a gallon. It usually runs about 1·280 sp. gr., but it should always be tested by the hydrometer, and the proper dilution ascertained before using.

Unlike the home-made concentrate, the commercial article leaves scarcely any visible deposit on drying. When spraying from two sides of the tree, this white deposit is a useful indication of the parts untouched by the former spray. Addition of a quart or so of milk of lime to the barrel of spray mixture will provide the necessary indicator for the commercial mixture.

3. Self-boiled Lime-Sulphur.

Fresh stone lime	8 pounds.
Sulphur	8 "
Water	40 gallons.

It is better to use 24-pound lots of lime and sulphur in order to get greater heat. Put the lime in a barrel with enough water to start it slaking. Then add the sulphur, which must be free from lumps; add water as necessary to complete the slaking; stir well, and when slaking is completed add water to cool it off and stop further action. Strain into the spray tank or barrel, and dilute to the amount indicated. This spray is used principally on peach foliage, or otherwise where Bordeaux mixture is liable to injure the foliage or fruit.

4. "Soluble Sulphur" or Soda Sulphur.

"Soluble Sulphur" or Soda Sulphur is a commercial product, which has not yet had sufficient testing to be recommended confidently. It varies little in price from the commercial concentrate, and unless it is shown to be superior to the latter, it will probably not replace it to any extent. It is very compact and easily dissolved for use.

5. Bordeaux Mixture.

The standard formula for this requires:—

Copper sulphate (bluestone)	4 pounds.
Unslaked lime	4 "
Water	40 gallons.

Dissolve the copper sulphate in a brass, graniteware, or wooden vessel in hot water, and then put in a barrel with enough water to make 20 gallons. Or it may be dissolved by suspending it in a sack over night in the barrel just below the surface of the water. Slake the lime thoroughly in cold or, better, hot water, and when slaked, add water to make 20 gallons. Mix the two 20-gallon solutions together, stirring constantly meanwhile. Strong solutions of the lime and sulphate should never be mixed. The mixture should then be strained into the spray tank or barrel.

The above directions apply to the making of Bordeaux in barrel lots. Where it is desired in larger amounts, tanks containing several barrels are used for the two

stock solutions. Stock solutions of each may be made up. The sulphate solution will keep a long time, subject, of course, to evaporation. The putty lime or milk of lime should be kept covered with water to exclude air.

A common defect in Bordeaux mixture is in having free or uncombined copper sulphate present. This may occur either by inaccurate measurement, mixing unequal amounts, or poor lime. Two simple tests may be made to determine insufficiency of lime. One is to add a drop of ferrocyanide of potassium to a saucerful of the made-up mixture. If it turns reddish-brown, the lime is deficient, and more of the milk of lime should be added to the mixture till further tests give no discoloration. Another less delicate test for free copper is made by thrusting a clean, bright knife-blade into the made-up mixture for a minute or two. The blade may first be freed from grease and dirt by stabbing it into the earth a few times. If the blade acquires a deposit of copper, more lime is needed.

6. Bordeaux and Resin Sticker.

For use with raspberries, onions, asparagus, and other plants, to which the ordinary mixture does not adhere.

Resin	1 pound.
Sal soda	½ "
Water	½ gallon.

Boil all together till the colour is of a clear brown. Add the amount above to each 40 gallons of spray.

7. Bordeaux and Iron Mixture.

Copper sulphate (bluestone)	2 pounds.
Iron sulphate (copperas)	2–3 "
Stone lime	4–5 "
Water	40 gallons.

Made similar to ordinary Bordeaux. For use on trees and vegetables where ordinary Bordeaux does not adhere well. The iron sulphate is not a fungicide in this case, but a less amount of the copper sulphate appears to be effective when used in conjunction with it. The iron sulphate costs from 1 to 2 cents per pound.

8. Ammoniacal Copper Carbonate.

Copper carbonate	4 ounces.
Ammonia (about)	2½ pints.
Water	40 gallons

Dissolve the carbonate in the ammonia, and add the water. Use only enough ammonia to completely dissolve the carbonate; excess of ammonia is to be avoided. The amount of it to be used will depend on the strength of the solution, which is variable.

9. Sulphur, Sublimed Sulphur, Flowers of Sulphur.

Used as a fungicide for Mildews. It has also been recommended as a substitute for self-boiled lime sulphur in some cases. It may be put on: (1) By dusting; this is the method used for peach and grape mildew; (2) By dusting in combination with lime (sulphur 1 part, lime 9 parts).

10. Corrosive Sublimate (Mercuric Chloride).

This may best be obtained in tablets, which cost about a cent each. One tablet makes a pint of solution of the usual strength used for disinfecting, viz., 1 in 1,000.

As the substance is a powerful internal poison, care should be taken that no persons or animals are allowed to drink the solution. It may be applied with a brush, or a swab made by rolling a strip of cloth around the end of a stick and tying it securely. This is the best disinfectant to use with Pear Blight, and it is valuable also for wounds and cankers of various kinds.

11. Formalin (Formaldehyde 40 per cent).

Formalin is a 40 per cent solution of formaldehyde gas in water, and is commercially obtainable in bottles containing about a pint (or a pound), and costing about 25 cents. As a 2 per cent solution of the gas is strong enough to use for disinfection washes, it is made up for use by mixing 1 part of the 40 per cent solution in twenty parts of water, or a pint bottle to 2½ gallons (=1 pail.) Since the gas passes off from the solution readily, the wash should be used within a day or two, and the bottle should be kept tightly corked. Formaldehyde fumes are irritating and injurious to the eyes, throat and lungs, but discomfort from this source can easily be avoided by handling it in open air or in a draft. Besides its use as a wash, or for disinfecting seed potatoes, etc., the dry gas is used as a disinfecting agent for tubers, bulbs, etc., in storage. These are disinfected by being placed in a tight room. For every 1,000 cubic feet of space, 3 pounds (or pints) of formalin are used. It is poured out in a dish, 23 ounces of potassium permanganate crystals are added, and the door closed for two days.

12. Paint.

White lead thinned with a little linseed oil is excellent for painting large wounds made in pruning, sun scald areas, cankers, etc.

13. Coal Tar.

Applied warm with a brush for the same purpose as paint. It is not to be used on peach trees.

14. Asphaltum.

Is used in the same way as coal tar. It is said to be without the ill results that follow the use of tar in some cases.

15. Florium.

A European coal tar product, which has the advantage of being miscible with water and hence can be sprayed on the tree. It is said to be a good wash for the trunk and limbs, having a valuable fungicidal action and stimulating the growth.

16. Whitewash.

Whitewash is in its simplest form lime and water, but other substances are sometimes added to make it adhere and last well. Glue, whiting, flour, tallow, and salt have been used for this purpose in varying amounts.

A good adhesive whitewash for trees, wounds, cankers, etc., may be made as follows:—

Lime (air-slaked)	30	pounds.
Tallow	4	"
Salt	5	"

Water sufficient to make it flow readily.

Whitewash has been used as a preventative of Sun Scald on the limbs of apple trees, where the trees have been severely pruned, and it is excellent for preventing rot in the large areas killed by winter.

HOW TO USE A HYDROMETER.

When lime-sulphur spray is used it should always be tested with the hydrometer, since there is usually considerable variation in the strengths of different lots, even when care is taken to make them as alike as possible. Even in the commercial lime-sulphur variations occur, and there is always the possibility of putting on a solution too weak to be effective or stronger than is necessary. The use of a hydrometer obviates such errors and gives assurance of the exact strength of the solution used. The hydrometer is merely a float which sinks higher or lower according to the strength of the solution in which it is placed. For convenience and accuracy in reading, a glass cylinder should be used in making the determinations, as then the figures and the surface of the liquid may be brought on a level with the eye. When the instrument is placed in a pail, as is sometimes done, exactness in reading is impossible. Such a cylinder can usually be obtained with the hydrometer, and the cost of both is in the neighbourhood of a dollar.

In making a determination the glass cylinder should be filled to within an inch of the top with the concentrate, which must be cold and free from sediment. The hydrometer is then placed in it, and the reading taken at the surface when the instrument is steady and floating free from the sides. After using, wash the hydrometer thoroughly, as the deposit which it would soon acquire from the drying of the solution on it destroys its accuracy.

Occasionally some confusion arises in the use of the hydrometer because of the two tables or scales in use on most of these instruments, one being that of Baume and the other that of the specific gravity. The latter is the best one to use, and the hydrometer readings given herein are according to specific gravity values. However, the accompanying table will enable any one to readily estimate the values of one scale in terms of the other.

In order to determine the amount of water to add to the concentrated solution to make it ready for use, proceed as follows: When the concentrate is cold and the sediment has settled, test its strength with the hydrometer in the manner just indicated. Suppose it reads 1·270, and we require for spraying a strength of 1·030; divide the last three figures of the reading just made (270) with the last three of the strength required (30) and the result will give the dilution, in this case 9, which means that we must mix 1 gallon of the concentrate and 8 of water. Similarly, if from a concentrate of the same strength (1·270), it was desired to make a spray testing 1·006, the dilution would be $\frac{270}{6} = 45$, or 1 gallon of the concentrate with 44 of water.

Table for comparing Baume's (B) and Specific Gravity (S.G.) values.

B.	S.G.	B.	S.G.
0	1·000	21	1·160
1	1·007	22	1·169
2	1·013	23	1·178
3	1·020	24	1·188
4	1·027	25	1·197
5	1·034	26	1·206
6	1·041	27	1·216
7	1·048	28	1·226
8	1·056	29	1·236
9	1·063	30	1·246
10	1·070	31	1·256
11	1·078	32	1·267
12	1·086	33	1·277
13	1·094	34	1·288
14	1·101	35	1·299
15	1·109	36	1·310
16	1·118	37	1·322
17	1·126	38	1·333
18	1·134	39	1·345
19	1·143	40	1·357
20	1·152		

USEFUL THINGS TO KNOW ABOUT MEASURES.

The imperial gallon is the one in common use, and is the measure used in this bulletin.

An imperial gallon of water weighs 10 pounds.
An imperial pint of water weighs 1¼ pounds.
A pint, wine measure, weighs 1 pound.
An ordinary teacup contains ½ pint.
A cubic foot holds 6¼ gallons.
An ordinary wooden pail holds 10 quarts or 2½ gallons.
An ordinary (oil) barrel holds 40 gallons.
Fifty gallons wine measure (used in United States)=40 gallons imperial (Canada).

LIST OF USEFUL BOOKS ON PLANT DISEASES.

Besides the numerous bulletins and other publications now constantly being issued, the following text-books on plant diseases are very useful, and one or more of them would be a valuable addition to every fruit-grower's library.

Ohio Handbook of Diseases of Cultivated Plants. (Bull. 214 Ohio Agr. Exp. Sta.).
Fungous Diseases of Plants, B. M. Duggar ($2.50).
Diseases of Economic Plants, Stevens & Hall ($2).
Diseases of Plants, H. Marshall Ward ($1.75).
Fungi which cause Plant Diseases, Stevens ($4).

SOME POINTS TO REMEMBER IN SPRAYING.

1. With lime-sulphur spraying on dormant wood, the object is to cover every part thoroughly. Where a double nozzle is used, the best results will be obtained by setting them at such an angle that where the spray strikes the tree, the edge of the spray cone from one nozzle will be at the centre of the cone from the other.

2. Spraying is most thorough when done from both sides of the twig, and changes of wind should be taken advantage of, so as to make sure of the spray reaching every part of every twig.

3. Low-headed trees are easier to cover than high trees, and in thick bushy growth it is very hard to reach every part.

4. Use plenty of hose. It saves times and spray mixture, and makes for more thorough work by enabling you to get around the tree farther.

5. Keep the pressure up. It means quicker work, there is greater force to the spray, and a finer mist with greater covering power is poduced.

6. Do not regard the spray on the ground as entirely wasted. It is doing good work in destroying spores on the fallen leaves and fruit, and those washed from the tree by rains.

7. When commercial lime-sulphur is used, there is no white deposit left to mark the parts covered by the spray, as in the use of the home-made article. A quart or two of milk of lime added to each barrel of spray will make a very useful indicator, the value of which will be duly appreciated when one comes to spray from the other side.

8. Sulphur dust does not do its work by covering the plant. The heat of the sun turns it into a poisonous gas (sulphur dioxide) which destroys the fungus. Put the sulphur where it will get hot best; even on the ground it is efficient to some extent.

9. Bordeaux mixture on foliage is not a wash. It is most effective on foliage when put on in small drops close together over the entire surface of the leaves. When so applied, any rain or dew in which fungus spores might germinate, dissolves enough poison from nearby spots of Bordeaux to kill the spore.

10. Do not forget that Bordeaux spray will not last forever. The leaves expand and new shoots appear, which need fresh protection. Also rains wash it off and leach out the fungicidal materials from it, so that it has to be renewed.

11. Remember that Bordeaux mixture, besides its fungicidal action, has a valuable stimulative effect on some plants.

12. The time for spraying is very important to observe. While there is considerable latitude in many cases, the best results follow when the work is done at the proper time.

13. Do not spray when the tree is wet, or when the temperature is below freezing.

14. Do not neglect the other trees and shrubs in the neighbourhood, which may have the same disease, and may transmit it to the orchard if they are not attended to.

15. In measuring materials for spraying mixtures and washes, gallons, quarts, and pints may be measured accurately enough for all practical purposes by filling up ordinary utensils with measured quantities of water, and then marking the height for future use.

16. Spraying is not a cure-all. It is a definite means for a definite and limited purpose.

17. Do not expect spraying to rid your orchard and garden of every pest. Many diseases cannot be controlled by sprays.

18. Spraying an orchard will not replace proper cultivation, fertilizing and pruning in any way.

19. Watch what the others are doing. You can learn a lot in that way, especially in regard to labour-saving and time-saving devices. Get all the advantage you can from the experience of others; it is a lot cheaper than acquiring it yourself sometimes.

20. If you fail to control a disease by a well-recommended treatment, consult the district representative or the Department of Agriculture about it, and they may be of assistance.

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